



Mosquito Control in Ontario
With Reference to
Larviciding Evaluations at
Mara Township

1972

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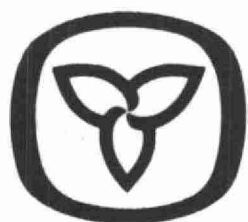
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Environment Ontario

MOSQUITO CONTROL IN ONTARIO

WITH REFERENCE TO

LARVICIDING EVALUATIONS AT

MARA TOWNSHIP

by

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and

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Biology Section
Ministry of the Environment
November, 1972

ALWT

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SUMMARY

A single, aerial application of Abate 4-E at 1.5 fl. ozs/acre was undertaken to control mosquito larvae in woodland swamps at Mara Township, County of Ontario. Larval mortality, spray drift and persistence of residues were assessed by ground surveying and the use of strategically-placed glass jars, while the influences of cover density, water depth and temperature were also investigated. The spraying gave generally poor results as determined by field evaluations and an adult trapping study. A questionnaire survey of residents within the control zone did not confirm or refute these findings and suggested only moderate concern over the biting problem. The incidence of mosquitos following the initial spring hatch was related to rainfall data for the two-week period prior to trapping. There are many unresolved problems surrounding current techniques for chemical control of mosquito populations and it is strongly recommended that large-scale larviciding be discontinued and greater emphasis placed on permanent methods of control. A Biting Fly Unit should be established within the Ministry of the Environment to study the entire question of biting flies and their control in Ontario. There is a pressing need to educate the public on the facts and uncertainties surrounding mosquito control programs and this would become a major objective of the Biting Fly Unit.

RECOMMENDATIONS

1. Large-scale, chemical larviciding programs for the relief of nuisance conditions caused by biting mosquitos should not be allowed to continue at the present time.
2. A Biting Fly Unit should be established within the Ministry of the Environment to examine the entire question of biting flies and their control in Ontario. Emphasis must be placed on permanent, rather than temporary measures of control and the public educated to improve understanding of the facts and difficulties relating to biting fly abatement.
3. As in the case of Mara Township, areas of the province having extensive wetlands together with mosquito outbreaks causing wide public concern, should have the benefit of advice from a competent drainage engineer and explore all possibilities of eliminating or reducing larval habitats.
4. Local and provincial authorities responsible for the development of recreational areas in the province should ensure that proper consideration is given to the disposition of natural mosquito habitats in relation to proposed development sites. Large-scale abatement programs cannot be entertained as a mechanism by which such development might be encouraged or approved for naturally infested localities.
5. Individual property owners anxious to reduce the severity of biting by mosquitos should be encouraged to use light traps and repellents, and to eliminate all reservoirs of stagnant water on their property. Under certain conditions the use of larvicides on private property may be justified.

INTRODUCTION

In many parts of the world where serious health problems develop from a high incidence of biting mosquitos, concerted efforts are made by state and local authorities to reduce mosquito populations utilizing the most sophisticated methods available. Such activities are highly organized, involve trained personnel and public funds and are carried out over the entire life-span of the mosquito, in some cases twelve months of the year. In recent times considerable emphasis has been placed on the eradication of eggs, larvae and pupae by chemical treatment of mosquito breeding grounds, although adulticiding operations are still an important secondary phase of many programs.

The Province of Ontario does not operate a comparable system of government-assisted mosquito abatement since no outbreaks of malaria have been recorded since the nineteenth century and the problem has been confined to nuisance conditions in recreational and suburban areas. While the severity of biting problems varies with location there are few districts in the Province which do not experience a mosquito outbreak during the late spring and early summer. The ubiquitous occurrence of snow pools in wooded areas following spring thaw renders the availability of suitable breeding grounds extremely widespread. In some places water level adjustment through dam installation and major landscape changes involved with highway and railroad construction have impeded drainage to the point where extensive flooding of low-lying areas occurs over much of the year. Moreover, drainage ditches with stagnant water, reservoirs, farm ponds, rain barrels, tin cans and discarded tires provide a myriad of potential larval habitats in almost every populated locality.

Undoubtedly man's activities have tended to increase mosquito populations in many areas although regional climatic conditions and topography must be regarded as the main factors underlying the prevalence of mosquitos in Ontario.

Since larviciding operations involve the addition of toxic chemicals to surface waters they are controlled through a permit system administered by the Water Quality Branch of the Ministry of the Environment (previously OWRC). Individuals, organizations or municipalities desirous of undertaking control programs are required to submit completed application forms to the Biology Section giving details of treatment areas, chemicals, dosage rates, timing and methods of spraying. Permits will only be granted to those applicants demonstrating a sound knowledge of the techniques required and where the proposed program is considered to have a reasonable chance of success. While recommendations for biting fly control have been in effect over the past decade the demand for information, advice and permits for mosquito abatement has been slight and has led to major spray programs only in the case of Mara Township, County of Ontario. The programs conducted in this area between 1968 and 1971 were the first and only mosquito larviciding operations authorized under the OWRC legislation and were the first attempts in Ontario at controlling mosquitos without the use of DDT which was not permitted for this purpose after 1966.

DDT is particularly effective against mosquitos. It is highly persistent and when applied to infested swamps will continue to control larvae for weeks and sometimes months after spraying. Relative to newer chemicals DDT is inexpensive to buy and simple to use since the timing of treatment is not critical. Applied early in the spring before the first population of mosquitos emerges, it may significantly reduce larval development for an entire season (Twinn 1955), although the Department of National Defense, working in central and northern Canada, found that two applications were generally required to give adequate relief (Winmill and Brown 1961). However, extreme

resistance to degradation and a high degree of solubility in animal fats renders DDT available for incorporation into living tissues and, ultimately, for translocation through food chains and accumulation in the fat deposits of higher animals. Since reproductive failure in birds and fish has been related to DDT residues it is unlikely that this insecticide will again be permitted for biting fly control purposes in Ontario.

The Biology Section and personnel of the Ministry of Natural Resources (previously Department of Lands and Forests) were instrumental in developing the mosquito control guidelines currently employed in Ontario. In addition, both agencies have taken an active role in evaluating and approving chemicals marketed by the pesticide industry for the control of biting flies. As a result, the insecticides authorized by permit are considered the most effective and least damaging to non-target organisms providing they are used at recommended rates and in accordance with the manufacturers' instructions. Unlike DDT, larvicides currently available are not stable in the environment and must be applied at the time when susceptible stages of larvae are present if good control is to be achieved. The chemicals registered at the present time include the organophosphorus compounds Abate, Malathion and Dursban and the organochlorine compound Methoxychlor. None of these chemicals can be considered truly specific for they are capable of killing a wide range of arthropods depending on the dosage administered. A degree of selectivity may be achieved where the target organism is the most susceptible form exposed and the amount of chemical applied is controlled with sufficient accuracy to protect more tolerant species. However, with the notable exception of Abate, current larvicides have many uses in addition to the control of mosquitos and even the most selective will effect a number of different invertebrate organisms. Field evaluations of black fly and mosquito larvicides indicate that significant numbers of mayfly and stonefly nymphs and caddis larvae may be killed by

single treatments although repopulation usually occurs within several weeks. In swamp situations and woodland pools the application of mosquito larvicides may have a severe impact on small crustaceans and water beetles but again, with single doses, no lasting damage has been noted. The impact of several treatments repeated each year may, on the other hand, be more severe but further work is necessary to explore this possibility. Compounds and dosage rates presently recommended do not appear to present a hazard to larger forms of life, including fish. However, partly due to analytical limitations, existing knowledge is notably deficient with respect to the persistence, accumulation and significance of larvicide derivatives. The disappearance of the applied chemical may indicate that degradation to another compound has occurred but such transformations do not necessarily give rise to less toxic materials. Uptake and retention by biological tissues may be additive and worthy of concern where repeated applications occur.

For these reasons, the Ministry of the Environment has adopted an approach to biting fly control which ensures that chemical quantities used do not exceed minimum effective dosages and that treatments are carefully restricted to known infested areas at times when optimum results should be obtainable. Such an approach requires that certain measures be taken prior to and during control programs. These include methodical mapping of all potentially infested areas within the treatment zone, field observations to confirm infestations and to follow the progress of larval development, consideration of possible interferences such as tree height, vegetation density and sediment type and, above all, meticulous calculation and metering out of chemical dosages required. Special emphasis is placed on pre-operational field work since, in the past, insufficient attention to this aspect of control programs has resulted in much overuse and misplacement of insecticide.

Despite more stringent requirements for program planning, the Ministry has not been satisfied that the technical and administrative procedures currently operative in Ontario are conducive to achieving efficient control of local mosquito populations. For present purposes an efficient control program may be defined as one which results in an appreciable reduction of adult or larval mosquitos without applying excess amounts of insecticide. In this context it is important to distinguish between an 'efficient' program and an 'effective' program, since effective control is mainly dependent on the intensity and extent of treatment and need not take into account the increased likelihood of undesirable side effects resulting from overuse of pesticide. It is inherent throughout this report that a mosquito control program should not be regarded as satisfactory unless an appreciable reduction of mosquitos can be achieved without excessive use of pesticide and without lasting damage to other, co-existing forms of life.

While recognizing that close attention to field survey work should provide the best means of reducing chemical usage, it was also evident that such measures would necessitate a more sophisticated involvement on the behalf of municipal authorities and commercial pest control operators than had previously been required. Past experiences with both these groups suggested that there would be some reluctance to extend activities beyond the actual application of pesticide. Another concern frequently voiced by the Ministry is that single applications of larvicide in early spring are unlikely to provide satisfactory control where successive populations of mosquitos occur. Two precisely-timed treatments with larvicide, followed by at least one aerial spraying with adulticide, are recommended by researchers and abatement agencies in other parts of the continent. Apart from the increased financial burden that this would impose on local rate-payers it is unlikely that the densely wooded mosquito habitat

frequently encountered in Ontario would allow for aerial spraying once the vegetation came into full leaf. In southern Ontario this normally occurs around the end of May, barely two weeks following the emergence of the first hatch of mosquitos. The use of granular formulations of larvicide might offset this difficulty but would greatly increase costs and would present a direct avenue of exposure to birds and small mammals through consumption of undissolved granules falling on dry ground.

Despite such problems, it was decided during the spring of 1970 that an attempt should be made to investigate the feasibility of affecting satisfactory mosquito control under circumstances typically faced by township authorities in southern Ontario. The objective underlying the investigations was to obtain a better understanding of the difficulties and limitations surrounding current practices and to provide a factual basis for development of future policies relating to mosquito control in this province. The studies which ensued included an assessment of the adult mosquito population over a summer season when no aerial application of insecticide was made, with an identical assessment over the subsequent season when a single large-scale larviciding took place in early spring. The larviciding operation was subjected to a detailed evaluation in order to ascertain the degree of larval kill and the influences of vegetation cover, tree height, water depth and temperature. Finally, a questionnaire was distributed to all rate-payers who were assessed for mosquito control to obtain insight into local attitudes concerning the need for these activities and their effectiveness to date. This report is therefore divided into three sections. The first deals with the adult mosquito trapping study undertaken in 1970 and 1971, the second discusses the evaluation of larviciding performed in 1971 and the final section reports the findings of the questionnaire circulated in August 1972.

The Study Area

The area chosen for study falls entirely within the boundaries of Mara Township, County of Ontario, and extends from a point on Lake Couchiching, 3 miles north of Orillia, to the Trent Canal where it leaves Lake Simcoe, 3 miles north of Beaverton. It consists of a low-lying clay plain dotted with drumlins which are composed of calcareous tills deposited by retreating ice at the end of the last glaciation.

Much of the low ground between the drumlins is scarcely elevated above the water table with the result that substantial areas of swamp are to be found throughout the township, particularly within a mile or two of Lake Simcoe. These swamplands had been sprayed for mosquito control on various occasions prior to the 1971 program. At the request of the township authorities permits were issued for larviciding operations in 1968 and 1969 with a second follow-up spray being applied in mid-summer of 1968 to control adult mosquitos. In addition, various applications of DDT are known to have taken place over the past three decades to control biting flies although no precise records are available.

Taxonomy and Ecology

Since it was not within the scope of this study to identify the major species of mosquito indigenous to the control zone, no taxonomic details are provided in this report. However, a number of samples of both larvae and adults collected throughout the various projects have been submitted to outside authorities for identification, so that any future control programs might benefit from a better understanding of specific habitat requirements and breeding seasons. At the present time this information is not available for the Mara Township study area.

'Not all species bite man and probably relatively few temperate species feed predominantly on man. The immature stages are always aquatic, but they rarely occur in large bodies of water such as lakes or rivers. Typical larval habitats are ditches, small ponds, pools, swamps, salt and freshwater marshes, water barrels, and more specialized habitats such as water-filled tree-holes. A few species survive the winter as hibernating adults, several others over-wintering as larvae. Aedine species belonging to the genera *Aedes* and *Psorophora* survive the winter mainly in the egg and/or larval stage. Their eggs are not deposited on the water-surface but amongst leaf-litter, soil, debris, or in mud at the edges of larval habitats. They can enter a state of diapause and withstand considerable desiccation. When flooded, some eggs may hatch almost immediately, whereas others will not hatch until several months or even years later. Eggs of most other genera are deposited on the water surface and are unable to withstand desiccation. *Aedes*, and in North America also *Psorophora*, species usually constitute the most important nuisance mosquitos in temperate regions, but in certain areas *Culex* and *Anopheles* species can also be troublesome'. (Service 1971).

The comprehensive paper by Steward and McWade (1961) provides much information on the ecology and distribution of mosquito species found in Ontario. From this work, it can be stated that representatives of the genera *Anopheles*, *Culiseta*, *Mansonia*, *Aedes* and *Culex* may all possibly occur within the study area although certain species of *Aedes* are likely to predominate. The species *A. stimulans*, *A. vexans* and *A. trichurus* are of particular interest and concern since they are common in southern Ontario and their larvae favour the woodland pool habitats which abound in Mara township close to the shore of Lake Simcoe. *A. stimulans* and *A. vexans* are prominent biters and the latter is known to produce a succession of generations, continuing late into the summer, under favourable conditions such as adequate rainfall.

SECTION I

ADULT TRAPPING STUDY

SECTION I

ADULT TRAPPING STUDY

There is a growing need for a practical and efficient method for assessing the effectiveness of mosquito control programs without having to rely on the subjective estimates of local residents. A number of techniques have been devised and tested, notably by workers in the United States, and these include blue cloth landing counts, exposed skin landing counts, light, carbon dioxide and truck-mounted traps. All of these suffer from certain disadvantages such that landing may be affected by wind conditions or may be selective for particular species, carbon dioxide dispersion is greatly dependent on wind and will tend to concentrate mosquitos from an area proportional to the dispersion, and light is of little use during daylight hours. The truck trap is somewhat more complicated to operate than the others, requiring the services of at least two people, and it is confined to areas accessible by road. However, the latter can be used at any time of day or night under all weather conditions and with regular use will yield a comparative index of the numbers of flying adults over a large area.

Since no spraying took place in Mara Township over the 1970 season, the opportunity arose to assess the mosquito population in a year when larval development was uninhibited and to obtain a numerical index for the population which might, when repeated the following season, be used to measure the effectiveness of the 1971 larviciding. A limited amount of thermal fogging was carried out in both years along roadsides adjacent to lakeshore residences, but this was mainly done 24-hours after the weekly trapping and it is felt that the restricted coverage and short-term effectiveness of the fogging would not greatly influence the results of adult assessments for the entire season.

The Truck Trap

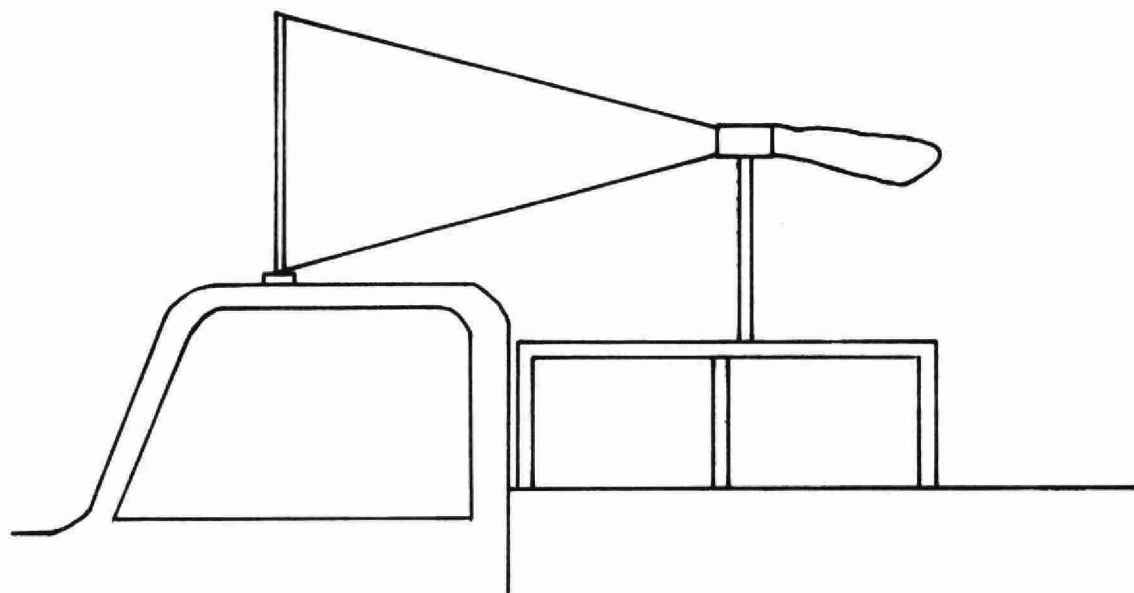
The trap net was constructed along the lines of that designed by Steelman et al. (1968) and utilized a lightweight Dacron netting with 196 openings to the square inch. The trap was supported by two wooden car-top carriers which were in turn mounted on a 1½" x 1-¾" wooden frame built to fit the rear of a ½-ton G.M.C. truck. A diagram of the unit is shown in Figure 1.

PROCEDURE

Before trapping commenced, it had been noted that the incidence of biting mosquitos was greatest in the late evening over an approximate 2-hour period encompassing sundown. This finding was consistent with reports in the literature which relate maximum numbers of flying mosquitos to the light and temperature conditions associated with the sun's progress during twilight hours. In recognition of this situation the trapping schedule at Mara was designed so that weekly monitoring took place at the same time in relation to sundown and over that period of evening when greatest numbers of adults are normally in flight. Starting times therefore advanced by a few minutes each week up until summer solstice and thereafter were gradually retarded as the days grew shorter. Sundown times for each week are given in Appendix 'A' while the schedule of trapping runs is graphically illustrated in Figure 2.

A series of three sampling routes was selected along the Brechin Beach shoreline of the township where a large number of vacation properties are situated and where extensive swampland lies immediately eastward of the residential zone. Figure 3 shows the location of the three routes in relation to Lake Simcoe, the town of Brechin and the recently established Lagoon City development. Routes 1 and 2 were each nine-tenths of a mile in length while Route 3 was eight-tenths of a mile.

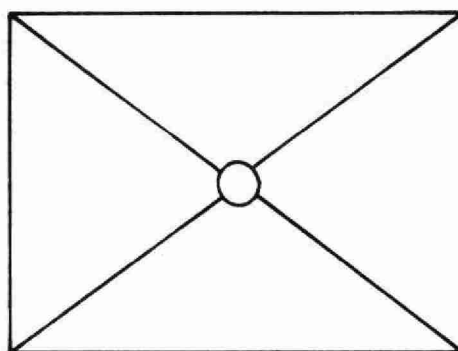
FIGURE 1. TRUCK TRAP FOR ADULT MOSQUITOES



SIDE VIEW

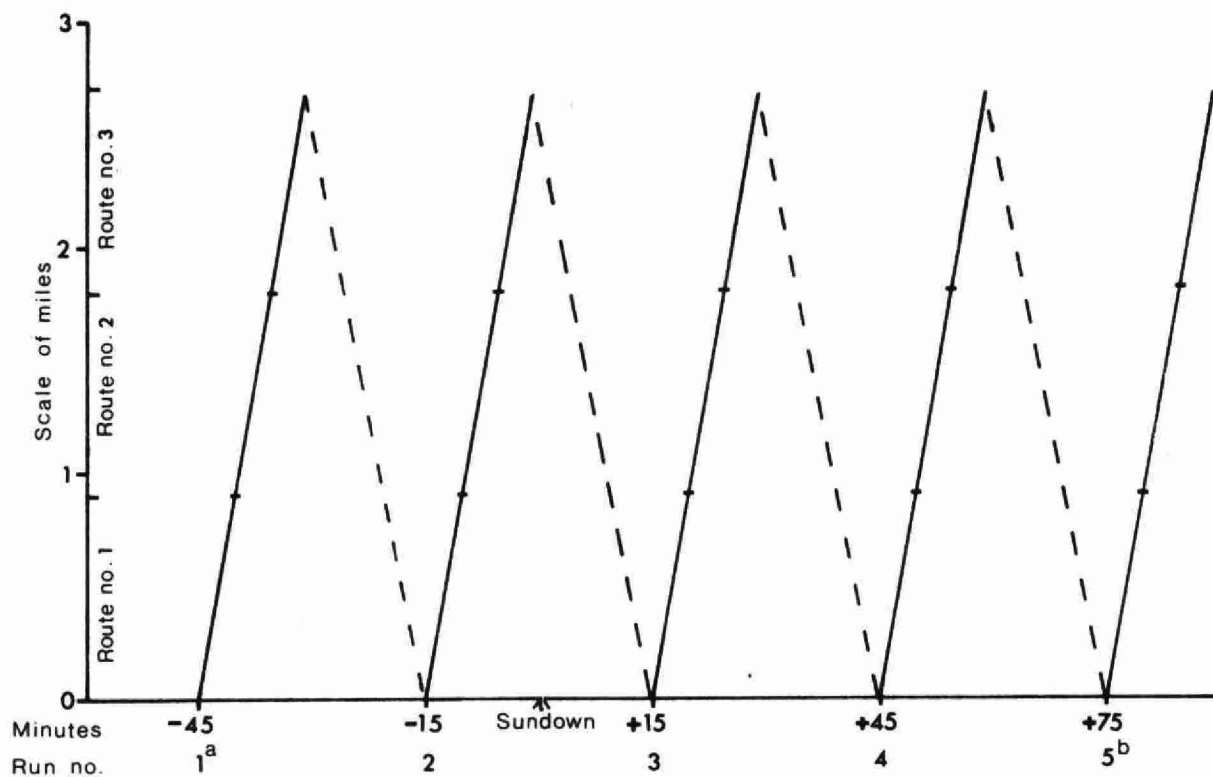


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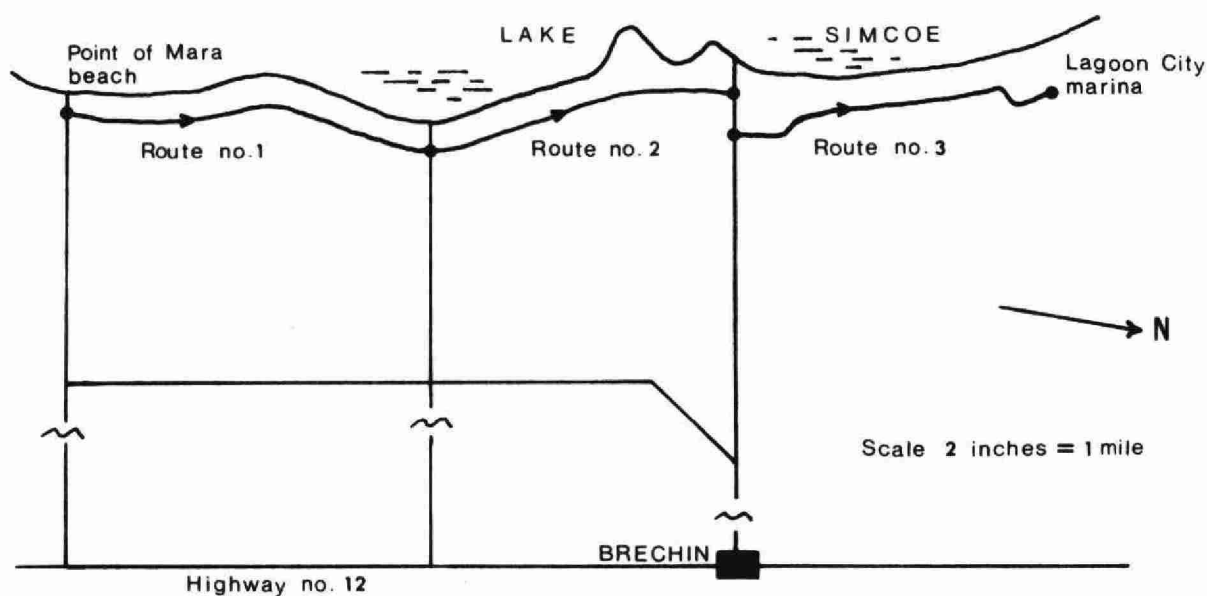
FRONT VIEW

FIGURE 2. TIMING OF RUNS IN RELATION TO SUNDOWN



^a Week nos. 1 to 4 and 16 to 19. ^b Week nos. 5 to 15.

FIGURE 3. LOCATIONS OF ROUTES



All routes were trapped four times each sampling night at thirty minute intervals. It will be noted from Figure 2 that over the period July 9 to September 17, 1970, the entire trapping schedule was advanced by one half hour. This mid-season adjustment was made following the observation that mosquitos tended to fly later in relation to sundown as the summer progressed. After September 17, the original trapping schedule resumed. A similar adjustment was made in 1971.

Air temperature was recorded at the start of Route 1 just before a series of three trapping runs was due to commence. Thus, four temperature measurements were made at this point each evening. In addition, a reading was made at the marina in Lagoon City immediately following the last run of the day.

Percentage cloud cover and the presence or absence of haze were likewise recorded at the start of each evening's trapping. Further estimates of sky condition were sometimes made where significant changes occurred as trapping progressed.

Assessments of wind velocity were subjective, being made on the basis of an arbitrary zero to five scale. Zero indicated no wind at all whereas five was the maximum at which trapping would be considered justifiable. Intermediate numbers were assigned on individual judgment, one (1) representing a barely perceptible breeze, two (2) a light wind, three (3) a moderately strong wind providing obvious tree movement and so forth. However, the data obtained from wind assessments may not have been representative of the region as a whole since local conditions are extremely variable at sundown, particularly close to large water bodies, and direction may change frequently over a short period.

Rainfall data were obtained from the Lorneville meteorological station, 12 miles south-east of Brechin, and figures are shown in Appendix 'A' for the total rainfall in inches over the two week period preceding each monitoring session.

Mosquitos caught in the net were retained in a small detachable bag at the back of the rig and at the termination of each run were placed into a glass etherized jar. Samples were labelled with the date and run number and transported to the Ministry laboratory in Toronto for sorting and counting. Mosquitos were separated from midges and other insects and were divided into groups of males and females. No attempt was made to speciate the adults nor to differentiate between biting and non-biting forms.

RESULTS AND DISCUSSION

The quantitative value of the truck-trap is contingent upon many variables, a number of which remain outside the control of the operator. Whereas it was possible to standardize the timing, speed and distance of the trapping runs, it was clearly impossible to offset the varying influences of temperature, wind and rainfall. However, these difficulties were recognized at the start of the program and it was decided that the sensitivity of the method in detecting changes from year to year could not be predicted until data had been obtained from at least two consecutive years. Much would depend on the number of adult mosquitos trapped and the degree of variation in climatic conditions. Since the ability to record meteorological data was extremely limited it was generally concluded that nothing short of a dramatic reduction in mosquitos captured would be indicative of significant change.

A complete tabulation of data obtained in 1970 and 1971 will be found in Appendix 'A'. The counts of adult mosquitos have been sub-divided into 'males' and 'females' since only female mosquitos will bite and their relative abundance is thus of interest, but the total numbers are used exclusively as indices

of control. In 1970, a total of 3107 mosquitos were captured of which 1805 (58%) were males and 1302 (42%) were females. Corresponding figures for 1971 were 2195, 1238 (56%) and 957 (44%). Therefore, there was a 29% reduction in numbers of adults trapped between 1970, when no larviciding took place, and 1971 when larviciding was undertaken.

Total numbers captured each week over both seasons are graphically related to temperature and rainfall (Figures 4 and 4a). Temperature is recorded as the median between the first and final readings obtained each night whereas rainfall corresponds to the total inches of rain over the 2-week period preceding each trapping night. As expected, evening temperatures were quite similar through each season and showed a declining trend from mid-August onward. A slight relationship is apparent between temperature and the number of mosquitos trapped during 1970 but not during 1971. On the other hand, there is a definite tendency for numbers of mosquitos captured to be positively correlated with rainfall over the preceding 2-week period. This relationship is stronger than with comparisons between 1, 3 or 4-week rainfall data, all of which have been tested. Presumably, the prediction that adult abundance would somehow relate to the prevalence of woodland pools, which form readily after moderate or heavy rain and provide temporary habitats for larval development, can now be validated to some degree. However, the relationship is seasonally dependent with respect to the mosquito life-cycle and rainfall obviously exerts less influence in early May when the first major hatch occurs coincident with snow pool formation.

Rainfall figures for 1971 were 24% lower than those for 1970. It may not be entirely coincidence that reductions in rainfall and numbers of mosquitos trapped are of the same magnitude. Table 1 compares temperature, rainfall and total catch data on the basis of periods corresponding closely to the

FIGURE 4. WEEKLY TRAPPING DATA 1970

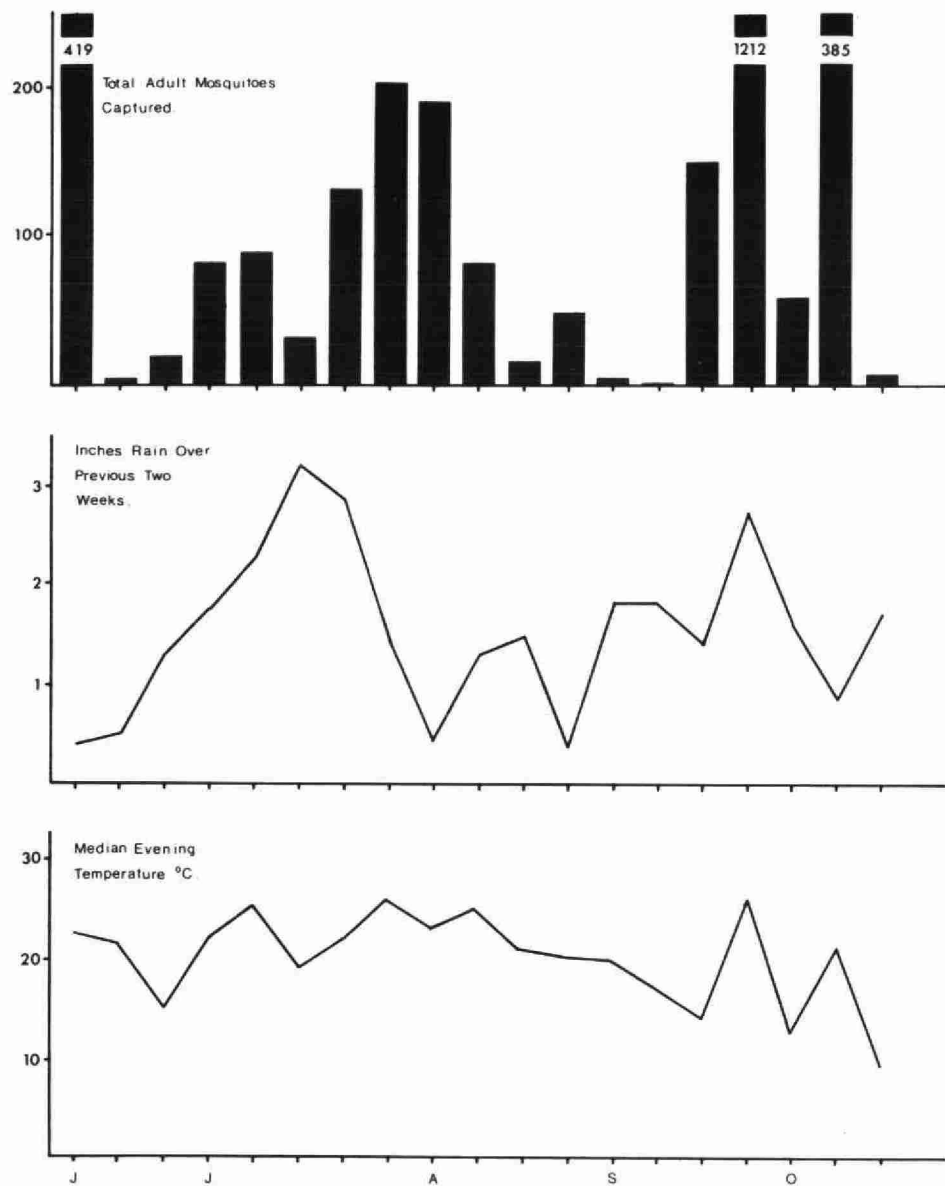


FIGURE 4a. WEEKLY TRAPPING DATA 1971

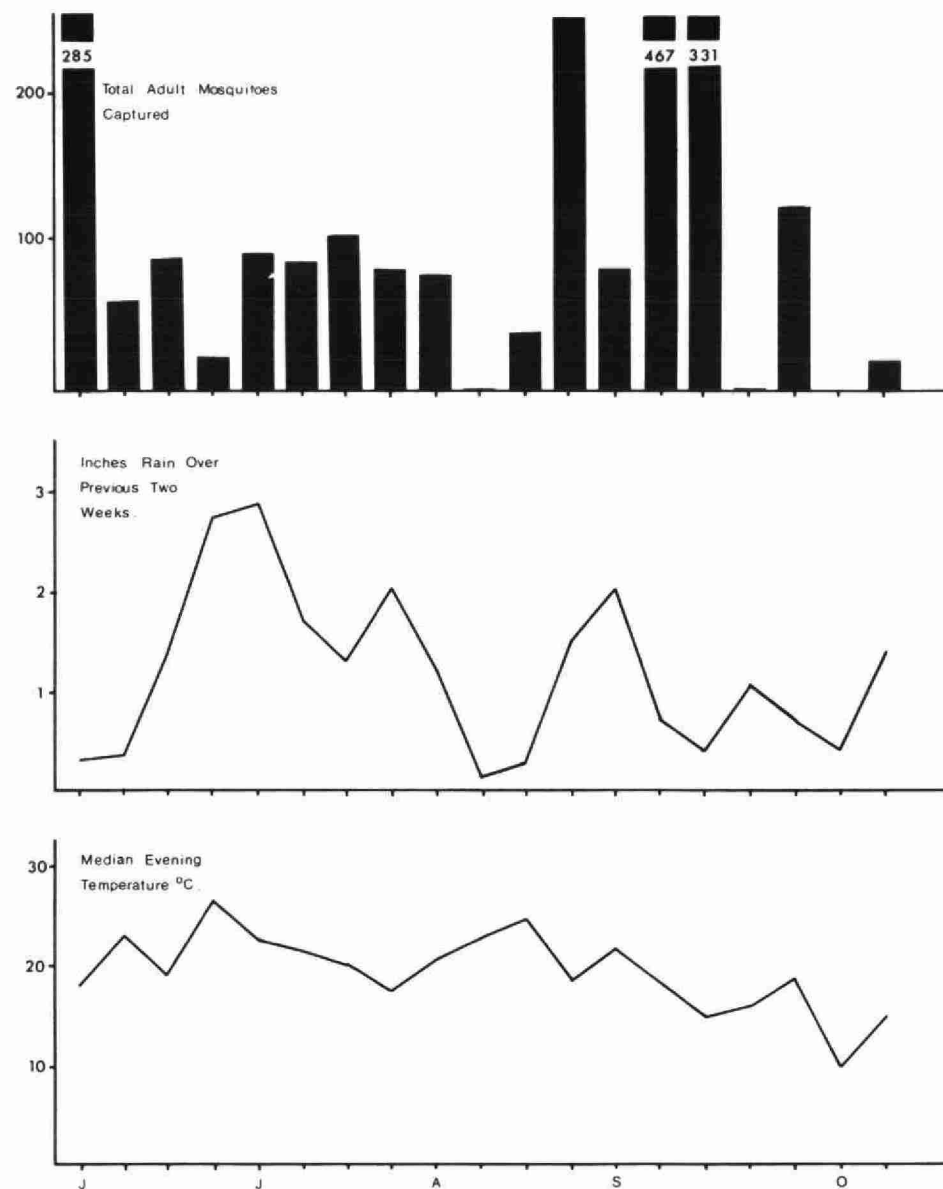


TABLE 1: SUMMARY OF MOSQUITO TRAPPING DATA - MARA TOWNSHIP
JUNE TO OCTOBER 1970 - 1971

Week Nos.	Mean Evening Temp. °C		Rain Index ^a		Inc. or Dec. %	Total Adult Mosquitos		Inc. or Dec. %
	1970	1971	1970	1971		1970	1971	
1 - 4	20.3	21.6	0.98	1.17	+ 19.4	516	449	- 13.0
5 - 8	23.1	20.3	2.5	1.96	- 21.6	465	367	- 21.1
9 - 12	22.3	21.6	0.88	0.76	- 13.6	319	360	+ 12.9
13 - 16	19.1	17.5	1.91	1.03	- 46.1	1361	880	- 35.3
17 - 19	14.1	14.3	1.36	0.80	- 41.2	446	139	- 68.8

^a Averages of two week rainfalls prior to each of four trapping weeks.

months of June through October for both years i.e. actual dates, and thus months, were not identical in both years. Parallel reductions in rain and mosquitos occurred in July, September and October while opposite and divergent shifts took place in June and August. Larviciding undertaken in May would likely exert the greatest impact on May and June adult populations and the small reduction in June 1971 (13%) may be deceptive since greater rainfall the second year (rain index up 19.4%) would tend to increase the size of the population. However, the change can hardly be considered significant in view of the catch sizes and serves only to indicate that climate probably exerts a far greater influence on mosquito density than a single application of larvicide.

Figure 5 illustrates the data from Table 2 in which the numbers of mosquitos trapped weekly are tabulated by run number. Runs 1 and 2 took place before sundown and runs 3-5 took place after sundown. Each run commenced 30 minutes after the start of the preceding run and required about 20 minutes to complete. The pattern of results is similar for both 1970 and 1971, with numbers of flying mosquitos reaching a peak soon after sundown. This finding suggests that twilight hours may be the most severe from the standpoint of biting, a characteristic of areas frequented by certain species of the genus *Aedes* (Bates 1949). The strong correlation between the numbers of mosquitos trapped and time of evening has further significance since it provides increased confidence in the quantitative value of the truck-trap method. The distribution shown in Figure 5, derived from total numbers obtained over the two years, was also evident on the majority of individual trapping nights as shown by the mean percentage figures for each run. Such consistency is most unlikely to occur through the use of a non-quantitative trapping technique.

FIGURE 5. NUMBERS OF MOSQUITOES TRAPPED IN RELATION TO SUNDOWN

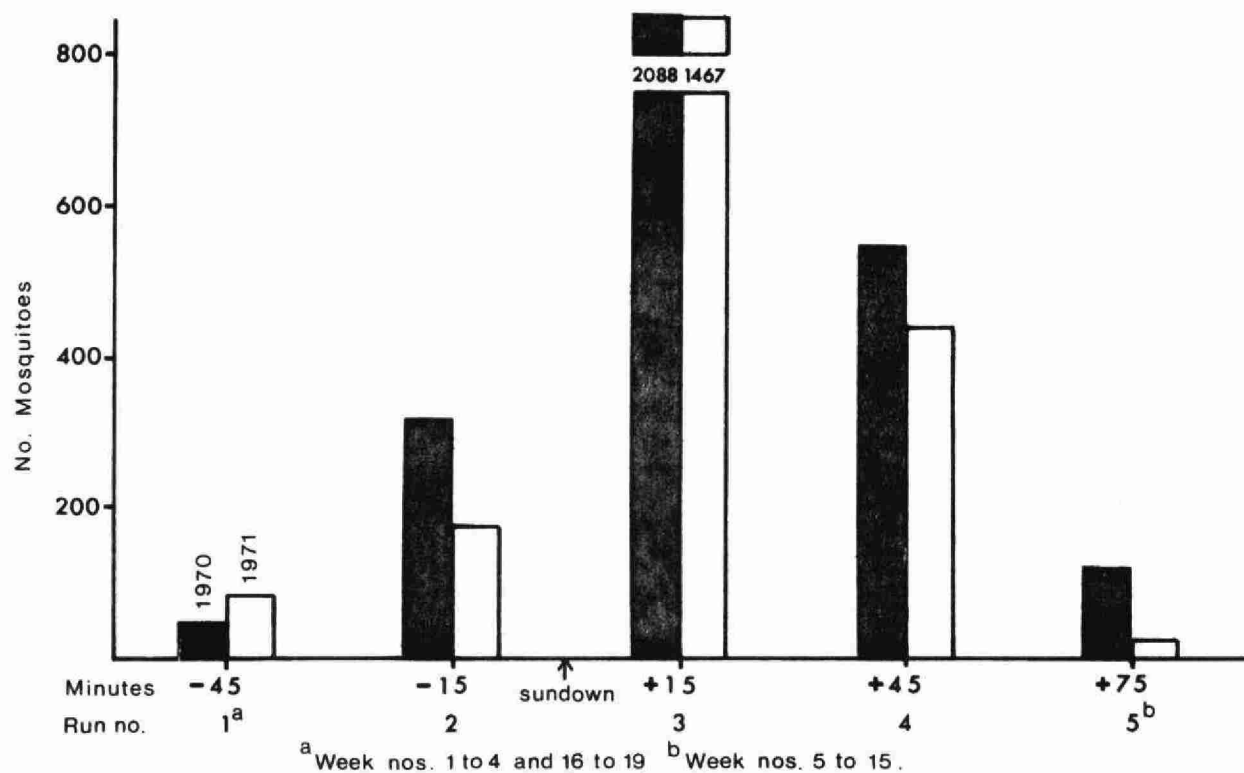


FIGURE 6. PERCENTAGE FEMALE MOSQUITOES TRAPPED WEEKLY

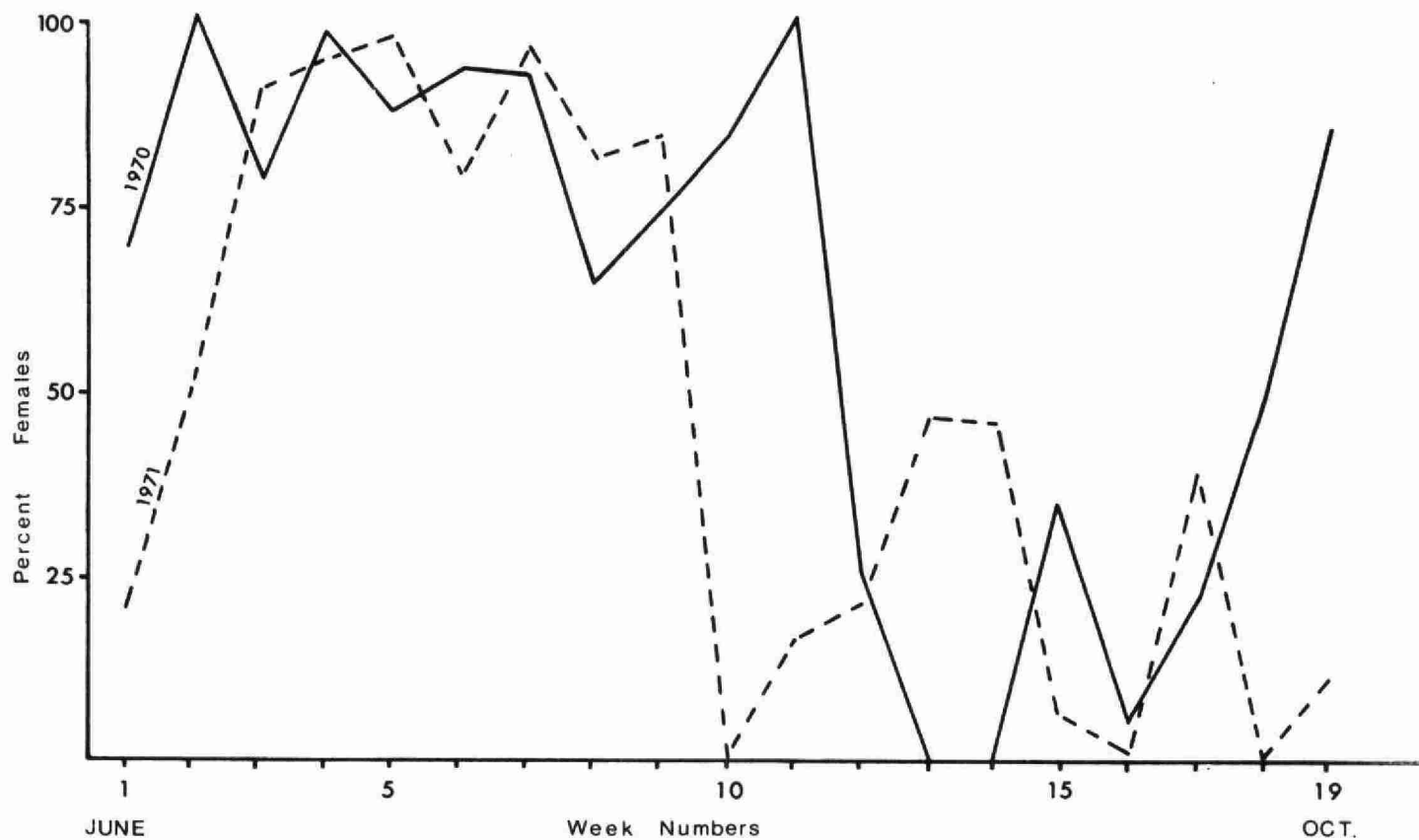


TABLE 2: NUMBERS OF ADULT MOSQUITOS TRAPPED WEEKLY IN RELATION TO SUNDOWN
1970 - 1971

Run No.	1		2		3		4		5	
	1970	1971	1970	1971	1970	1971	1970	1971	1970	1971
Week No.										
1	0	63	36	122	347	94	36	6	-	-
2	1	0	0	4	2	43	0	7	-	-
3	0	0	2	0	14	31	3	60	-	-
4	0	0	2	0	36	1	36	18	-	-
5	-	-	0	0	1	0	68	93	37	1
6	-	-	1	0	6	18	19	65	3	6
7	-	-	0	5	46	48	73	48	9	4
8	-	-	0	0	S 38	37	136	40	28	2
9	-	-	3	0	U 93	27	80	43	10	3
10	-	-	1	0	N 17	0	51	1	7	0
11	-	-	0	0	D 14	34	0	2	0	1
12	-	-	1	1	O 36	244	6	4	0	0
13	-	-	0	0	W 3	74	0	5	0	2
14	-	-	0	9	N 1	430	0	25	0	3
15	-	-	134	10	10	314	1	7	0	0
16	0	0	3	0	1187	1	22	0	-	-
17	43	20	10	43	0	56	1	2	-	-
18	14	0	122	0	235	0	14	0	-	-
19	1	3	4	-	2	15	0	0	-	-
Sub Totals	59	86	319	194	2088	1467	546	426	94	22
Percent of Grand Total	2	4	10	9	67	67	18	19	3	1
Mean Percent - age of nights sampled.	16	7	12	5	53	51	24	37	7	2

Figure 6 shows the percentages of female mosquitos taken weekly in 1970 and 1971. Females outnumbered males from June to early August during both years with a subsequent reversal of this condition for the remainder of the study period. The biological significance of this marked shift in proportions of the sexes is not understood but it does suggest that the incidence of biting is likely to diminish over the latter part of the mosquito season.

SUMMARY OF TRAPPING STUDY

1. The number of adult mosquitos captured by truck-trap in 1971 was 29% lower than in 1970. Rainfall data showed a similar reduction of 24%. It is concluded that rainfall played a more significant role in regulating the abundance of mosquitos each year than the single application of larvicide in early spring.
2. The greatest number of flying mosquitos occurred immediately after sundown. The consistency of the trapping data in relation to sundown confirms the quantitative reliability of the truck-trap method for measuring and comparing magnitudes of mosquito populations.
3. The ratio of females to male mosquitos was significantly higher between June and mid-August than between mid-August and the end of October.

SECTION II

LARVICIDING EVALUATION

SECTION II

LARVICIDING EVALUATION

It has been stated in the Introduction that an important feature of this evaluation was the decision to conduct a larviciding operation which would parallel those typically undertaken by Ontario municipalities. It was also mentioned that the requirements for pre-operational field surveying, imposed by the Ministry in 1971, would likely meet some opposition primarily due to the economic implications and skepticism that specialized technical abilities were needed. Since the larviciding was to be given every chance of success within the limitations imposed both by provincial regulations and the techniques and finances available to the township, it was agreed that Ministry personnel would assist the township with the pre-operational studies so that both parties would benefit from the experience.

METHODS

In preparation for the pre-larviciding survey which would more precisely define mosquito breeding areas in Mara Township, a map was drafted showing all potential larval habitat (Appendix B). A township map, prepared by Inducon Consultants of Canada Limited on a scale of two inches to the mile was utilized for this purpose. With the aid of aerial photographs and topographic maps, all low-lying areas were superimposed on the township map, acreages of each area were calculated and numbers were assigned to every plot representing stations to be surveyed in early spring.

On April 21, crews from the Biology Section assisted by Mara Township personnel commenced the initial survey of potential breeding grounds. At each planned check-point, as

well as other likely locations not shown on the map, measurements were made of water depth, temperature, percent water coverage and larval size and abundance. Descriptions of cover type, density and height were recorded. Samples of mosquito larvae were collected for future reference. Acreages of potential treatment areas were reassessed and all data were recorded on specially prepared survey forms. The above measurements and descriptions were undertaken according to the instruction sheet provided to each survey crew (Appendix C).

Cover categories were determined by the amount of sky coverage as observed from the ground, and were broken down as follows:

- Open - No cover
- Light - Up to 10% sky coverage
- Moderate - Over 10 and up to 30% sky coverage
- Dense - Over 30% sky coverage

Whereas larval abundance was initially estimated according to the instructions shown in Appendix C, it was later determined that, even where extremely abundant, larvae tended to occur in dense aggregations over limited areas of the plots and were easily visible to the unaided eye. As a result, it was decided to dispense with the netting technique following the first survey and to appraise larval abundance by direct observation and according to the following guidelines:

- Present - Occasional larvae
- Plentiful - Occasional dense aggregations of larvae
- Abundant - Frequent dense aggregations of larvae.

Surveys of all stations were repeated at intervals of various duration depending on the rate of larval development, and as uninfested plots were identified these were deleted from the treatment schedule. When larvae appeared to be nearing their peak of abundance in certain plots the commercial pesticide applicator was notified. Larviciding commenced on May 7th, and

plots larger than one acre in size were treated by aircraft with Abate 4E emulsifiable concentrate in water. The application rate was 1.5 oz. of pesticide, or one gallon of mixture per acre. The aircraft utilized was a Bell 476-2 helicopter equipped with a 32 foot Simplex boom with TEE JET 8003 nozzles. Loading of the aircraft was supervised by a member of the Biology Section who also measured the quantities of chemical added to each tank load of spray mix. Mixing of water and Abate was accomplished by first introducing the concentrate to the tanks and then adding the required volume of water. A mobile tank trailer, previously filled from the most convenient source, supplied the dilution water. The pesticide was applied in a swath 100 feet wide while the aircraft was travelling at 40 m.p.h. at a height of approximately 100 ft.

Over the period of May 7th to May 15th inclusive approximately 3800 acres were treated. Plots less than 1 acre in size were manually treated with Abate 5C Capsules (one capsule per 1000 sq. ft.) or Abate 2-G Granular (2% at 5 lb per acre). Two small ponds were sprayed with Flit MLO, a mineral oil product, at rates of two and five gallons per acre (See Appendix D).

In the course of the pre-larviciding surveys, five survey stations were selected for monitoring wherein the effectiveness of the larviciding, under various conditions of cover type and water depth, could be evaluated in detail. Assessments were carried out according to the Methods for Evaluation of Mosquito Larviciding (Appendix E). The objectives of this monitoring were as follows:

- (1) To measure the amount of larvicide actually reaching the swamp as compared to concentrations theoretically achievable with complete and uniform distribution of the spray.

- (2) To measure the extent of chemical adsorption to organic material and to relate this to reduced toxicity against larvae.
- (3) To measure the degree of spray drift outside the treatment area.
- (4) To measure the persistence of Abate larvicide in swamp water. For this purpose, samples of swamp water were collected at Point E immediately after spraying and after 1, 2, 4 and 7 days.

Water and leaf litter samples were analyzed for Abate residues by the Ontario Pesticide Residue Testing Laboratory of the Ontario Department of Agriculture and Food in Guelph. In order to avoid the possibility of chemical degradation water samples were transported to the testing laboratory as rapidly as possible. A description of analytical techniques involved is located in Appendix F.

24-hour post treatment checks were made in order to assess larval mortality on many plots other than those with monitoring stations including ponds treated with capsules, granules and Flit MLO. In all cases the degree of control was rated in accordance with the following guidelines:

Satisfactory	-	Code S	-	Control of the vast majority of larvae.
Unsatisfactory	-	" U1	-	An obvious reduction in larvae.
"	-	" U2	-	Some reduction in larvae but the majority alive.
"	-	" U3	-	No apparent reduction in larvae.

At monitoring stations, estimates of control were made by observing the incidence of surviving larvae in pools adjacent to Points D and E. Post-treatment surveys of entire plots, however, involved considerable walking over extensive areas in order to assess the degree of control achieved.

The Larvicides - Technical Information

The larvicides selected for use in this evaluation consisted of three formulations of Abate, marketed by Cyanamid of Canada Limited, and Flit MLO marketed by Imperial Oil Limited.

The major part of the spraying involved aerial applications of Abate 4-E (emulsifiable concentrate) mixed with water. The choice of this larvicide stemmed from its acceptable performances in field tests conducted by the Ministry in recent years and the knowledge that, by careful control over the dosage applied, effects on non-target organisms can be limited to a degree rarely exceeded by alternative compounds. The chemical name of Abate is O,O,O', O' - tetramethyl O,O' - thiodi-p-phenylene phosphorothioate. It has a relatively low toxicity to mammals and birds although the high concentrations incorporated into granular formulations may present a hazard to birds exposed to the granular material. A reasonable margin of safety exists between levels acutely toxic to fish and the highest levels anticipated from biting fly control activities. Bioassay tests undertaken by the Ministry showed 24-hour TLM's for the fathead minnow (Pimephales promelas), crayfish (Orconectes virilis) and stonefly (Togoperla media) of 6.2, 4.9 and 0.56 ppm respectively. At 3.2 ppm fathead minnows were unaffected after 96 hours (Swabey et al, 1967). At 1.5 fluid ozs/acre, the highest recommended application rate and that used in this study, Abate 4-E would achieve an initial concentration of 0.06 ppm in 1 foot of water providing all the chemical reached the target and was uniformly distributed. Under laboratory conditions Abate has been shown to kill several species of larvae at concentrations as low as 0.001 ppm within 24 hours (Lofgren et al, 1966). However, in the field situation the tendency of Abate to combine readily with organic material, particularly sediments, renders it necessary to employ greater amounts if sufficient larvicide is to

remain unbound to effect the larvae. Bowman and Orloski (1966) investigated the residual life of Abate in water and sediments of ponds and streams. They found no accumulation of the parent compound even with repeated applications at exaggerated rates, but the method of analysis was not sufficiently sensitive to predict the duration of larvicidal concentrations (10 ppb) nor were any details provided as to the turbidity of the water, nature of the sediments, or the form and quality of breakdown products. Nonetheless, it was clearly shown that the Abate parent compound disappears rapidly from water with up to 95% reduction in 24 hours. Two other formulations of Abate were used where small plot sizes or isolation from main flight paths did not justify aerial spraying with emulsifiable concentrate. These were Abate 2-G, a granular formulation containing 2% active ingredient, and Abate 5C capsules each capsule containing 0.26 grams active ingredient. They were applied by hand at 5 lbs/acre for granules and one per 1000 sq. ft. for capsules.

Flit MLO is a low-viscosity, colourless petroleum oil which is reputed to control mosquito eggs, larvae and pupae. A small quantity was supplied by the industry for testing purposes and was applied to two ponds at separate rates of 2 gals and 5 gals acre using a back-pack sprayer. The results are summarized in Appendix D.

RESULTS AND DISCUSSION

General Observations

Because of the heterogeneous nature and large size of many potential mosquito breeding grounds, and the limited time and manpower available, it was often difficult or impossible to classify various features of the plots or to determine the precise extent of infestation. Larval development was often at different stages within the same plot and occasionally within the same pool. Temperature and water depth likewise varied considerably within a small area. Nevertheless, all survey information obtained has been summarized in Appendix G.

Mosquito larvae were observed in most of the major plots delineated on the map as well as in a number of small pools not detected on the aerial photographs. Certain types of wet area appeared to be unsuitable for mosquito development, including cattail stands, areas of flooded land adjacent to running water and open pools in grassy areas where larger plant life was absent. It was also noted that areas with extreme water depth (<1.5 ft) tended not to support larvae at this time of year.

Few larvae were observed anywhere during the initial survey (April 20-22) when water temperatures during the day (11.00 a.m. to 5.00 p.m.) were averaging less than 10°C. However, when the next survey was undertaken on May 3, larvae were approaching maximum density in some areas and averaged over 4 mm in length. Daytime water temperatures on this occasion were generally greater than 15°C. Since Abate has been suspected of inducing pupation in late instar larvae and is ineffective against pupae or eggs, it was the intention to spray plots when maximum

numbers of second and third instar larvae (3-7mms) were present. However, the onset of warmer water temperatures and consequent development of larvae simultaneously in many plots, rendered it impossible to treat under optimum conditions in all cases. Figure 7 shows the relationship found between the sizes of larvae and water temperature.

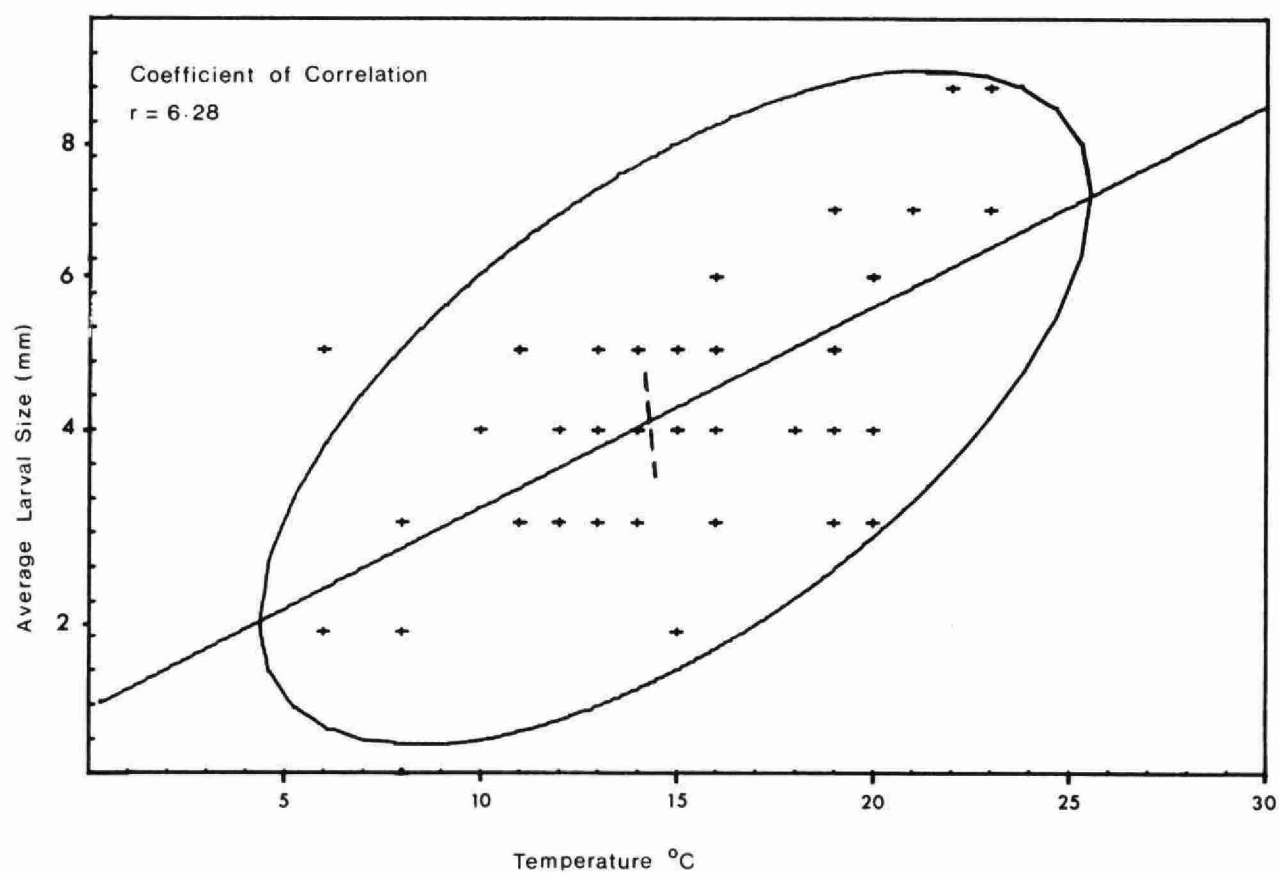
As the program progressed, it became apparent that several factors in addition to larval development were to seriously affect the spray schedule. The great distances between some of the plots made it uneconomical to treat all areas from one central point, thus the landing and loading base had to be relocated on several occasions. Weather conditions also played a major role in the timing of applications. Because of the probability of drift away from the treatment areas no spraying could be undertaken when wind velocity exceeded 5 m.p.h. In addition, bright mid-day sun caused the spray droplets to evaporate after they were emitted from the nozzles, leaving pesticide vapour suspended in mid-air and highly susceptible to upward movement through the action of convection currents. As a consequence it was found that under apparently ideal flying conditions little or no spray reached the swamps. The combined effect of these difficulties was that spraying had to be restricted to a few hours each day, some plots were treated when conditions of larval development were less than ideal and one major plot was not treated at all since the many delays forced the applicator to terminate his stay and embark on other commitments.

Monitoring Stations

Throughout this discussion the following details should be borne in mind;

1. At each monitoring station there were 5 monitoring points situated at 100 ft intervals along a transect

FIGURE 7. PRINCIPAL AXIS FOR THE CORRELATION OF LARVAL SIZE WITH DAYTIME
WATER TEMPERATURES



Graph includes 95 percent confidence ellipse on the data.

running at right angles to the edge of the plot (Figure 8). Monitoring points were designated letters A to E commencing with the point situated 200 ft outside the plot.

2. Assuming uniform dispersal of the chemical, the concentration in jars placed at monitoring Points C, D and E (those within the plot) would be 0.12 ppm, equivalent to 0.06 ppm in a swamp 1 foot deep.
3. All larvae in control jars survived the post-treatment period. Larval mortality in test jars was recorded 24 hours after spraying.
4. The averages for tree height and water depth, calculated from all plots surveyed, were 40 ft and 8 ins. respectively.

Percentage mortalities of larvae held in jars at the various monitoring stations are shown in Table 3, while corresponding estimates of control in the pools adjacent to Points D and E are included in Table 4. In all cases where satisfactory (S) control was observed, 100% mortality of larvae occurred in the neighbouring jars while unsatisfactory (U_1 - U_3) control was recorded wherever partial or zero jar mortality was found. This finding supports the contention that the effectiveness of larviciding may be reliably monitored through the use of test jars.

Results obtained at the five monitoring stations are discussed individually, as follows:

FIGURE 8. GRAPHICAL EXPLANATION OF SURVEY STATIONS, MONITORING STATIONS
AND POINTS IN RELATION TO PLOTS

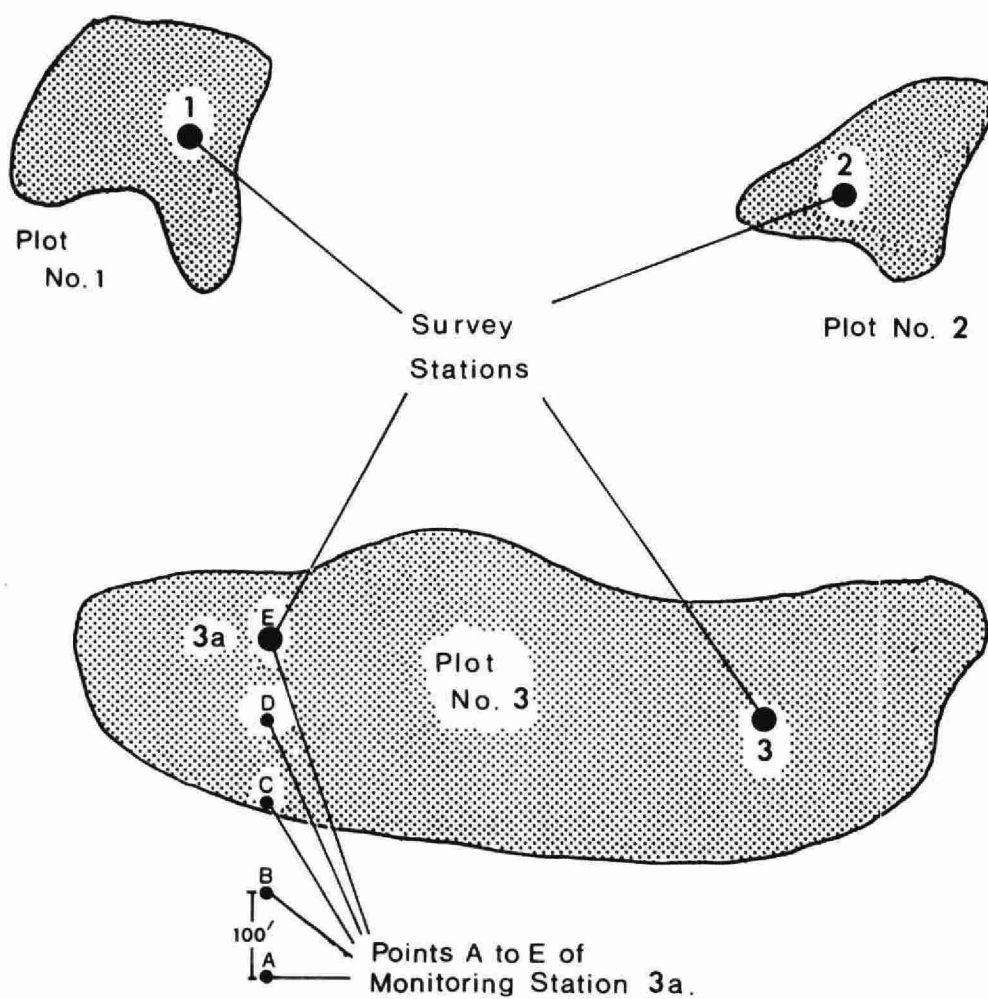


TABLE 3: ABATE CONCENTRATIONS (ppb) AND PERCENT LARVAL MORTALITY
IN JARS AT MONITORING POINTS

Monitoring Point Hours Post-Spray	Outside Swamp → ←					Inside Swamp		
	A		B	C	D	E		
	0 ppb	24 % kill	24 % kill	24 % kill	24 % kill	0 ppb	24 ppb	% Kill
Station No.2								
Control		0	0	0	0			0
Water	N.D.			100	20	14.0	N.D. ^x	- φ
Water & Litter		10	0	100	0		N.D. ^x	- φ
Litter							- φ	
Station No. 4a								
Control		0	0	0	0			0
Water	0.4			-φ	0	0.4	tr.	100
Water & Litter		100	30	-φ	0		0.1	100
Litter							- φ	
Station No.12								
Control		0	0	0	0			0
Water	N.D.			100	100	5.0	- φ	100
Water & Litter		20	0	100	100		2.5	100
Litter							200.0	
Station No.24								
Control		0	0	0	0			0
Water	N.D.			0	0	2.0	10.0	100
Water & Litter		10	0	0	0		N.D. ^x	100
Litter							1500.0	
Station No.31								
Control		0	0	0	0			0
Water	tr.			-φ	100	8.7	6.0	100
Water & Litter		40	50	90	-φ		3.0	100
Litter							5000.0	

φ Interference; No data

x Jar overturned, sample taken at D

Detection limits - Water 0.1 ppb

- Litter 10.0 ppb

TABLE 4: ABATE CONCENTRATIONS (ppb) AND DEGREE OF LARVAL CONTROL
IN SWAMP AT MONITORING POINTS

Hours Post-Spray Monitoring Point	0	24			48	96	1 week
	E ppb	D Control	E	E ppb	E ppb	E ppb	E ppb
Station No.2							
Swamp Water	18.0	U ₃	S	1.5	N.D.φ	N.D.φ	N.D.φ
Litter				750.0			
Station No.4a							
Swamp Water	0.4	U ₃	S	0.1	1.0	N.D.	N.D.
Litter				330.0			
Station No.12							
Swamp Water	9.0	S	S	0.1	N.D.	2.0	tr.
Litter				50.0			
Station No.24							
Swamp Water	25.0	U ₃	S	tr	-	N.D.	N.D.
Litter				-			
Station No.31							
Swamp Water	8.7	S	S	6.0	-	N.D.	N.D.
Litter				-			

φ Sample taken from D.

Detection limits - Water 0.1 ppb
- Litter 10.0 ppb

Station 2

This station was characterized by moderate deciduous tree cover of less than average height. The water depth of 10 inches was significantly greater than that of other monitoring stations. The plot was sprayed early in the schedule when larvae were relatively small, yet maximum numbers had been attained. Mortality in jars without litter at Points C and D after 24 hours was 100% and 20% respectively but, due to animal interference, comparable figures were not obtained from Point E. Control of larvae in the swamp adjacent to Points D and E was rated unsatisfactory (U₃) and satisfactory (S) respectively, suggesting that jar mortality at E was likely 100%. These findings reflect conditions observed throughout the plot which was typified by sporadic control with larval mortality ranging from zero to total from place to place.

Whereas 20% mortality was noted at Point D in the jar without sediment, there was total survival of larvae in the jar containing leaf litter. Chemical analyses are not available for water and litter in jars at this Point but it is likely that toxicity was reduced in the latter container by adsorption of chemical onto the organic material.

Partial mortality (10%) occurred in the open jar at Point A, 200 ft outside the plot, although the Abate concentration was below the limit of detection. Presumably, minute quantities of larvicide had drifted away from the plot and were sufficient to cause limited mortality amongst the test larvae.

Station 4a

Moderate deciduous tree cover of less than average height and shallow water combined to produce ideal spraying conditions at this station. Furthermore, the plot was treated

at an early stage when larvae were small and therefore more susceptible to the larvicide. However, no mortality was recorded in either jars or swamp at Point D whereas the effect at Point E was quite satisfactory with good control in the swamp and 100% mortality in both test jars, with and without leaf litter. Interference from animals resulted in no data from Point C.

Considerable drift occurred at this station as evinced by 100% and 30% mortality in uncovered jars at Points A and B respectively. The general estimate of control in Plot 4a as a whole was similar to that in Plot 2, being quite irregular from place to place throughout the swamp.

Station 12

This monitoring station, characterized by light tree cover and shallow water, was treated when larvae were at an advanced stage of development in comparison with Stations 2 and 4a. It was exceptional in that satisfactory control was achieved both within the swamp itself and the jars at Points C, D and E. Point A, outside the plot, showed some mortality of larvae although the concentration of Abate in the jar was below the detection limit. Similar to other monitoring stations levels recorded in jars at Point E were well below the predicted concentration of 120 ppb.

In general, excellent control of larvae was achieved throughout this plot probably due to the minimal interference from tree cover combined with shallow water and thus low dilution of larvicide.

Station 24

Tree cover here was more substantial than at most monitoring stations and consisted of tall, moderately dense deciduous growth while water depth was somewhat below average.

The plot was treated late in the schedule when larvae were well advanced but no pupae were observed prior to spraying. No control of larvae occurred either in jars or swamp except at Point E, where 100% mortality occurred in jars with and without litter and the effect on larvae in adjacent pools was rated satisfactory. Once again some drift was apparent resulting in 10% mortality of larvae in the uncovered jar at Point A.

It was noted in the post-treatment survey that some pupation had occurred in Plot 24 but it is not known whether this resulted from larviciding or normal mosquito development. The general estimate of control throughout this plot was most unsatisfactory (U_3) with the majority of larvae surviving treatment.

Station 31

Substantial deciduous tree cover existed at this station and throughout the plot while water depth was around average; except at Point E where a depth of 14 inches was recorded and tree cover was light. Larvae were well advanced at the late treatment date but no pupae were observed up to that time. Nonetheless, control was satisfactory in the swamp both at Points D and E and 100% mortality was recorded in the corresponding jars. At Point C, on the periphery of the plot, 90% mortality occurred in the jar with leaf litter while the jar without litter was overturned by animals. Drifting was again detected with 40% and 50% mortality reported from jars at Points A and B respectively.

The overall rating assigned to Plot 31 was very unsatisfactory control (U_3) since the majority of larvae throughout the swamp survived treatment. In this case, results obtained from the monitoring station were not representative of the entire plot.

Concentrations of Abate in Jars

Included in Table 3 with the data on larval mortality are the analytical results for Abate concentrations in jars at Points A and E. At each monitoring station, water samples were taken at Points A and E immediately after spraying from glass jars containing 1 litre of water but no larvae or leaf litter. After 24 hours, further water samples were taken at Point E from both the jars with larvae and litter and the jars containing larvae alone.

Abate concentrations at Point A, outside the plot, were undetectable in three cases although larval mortality occurred over the succeeding 24-hour period. Evidently, this larvicide can be effective at extremely low levels and far below concentrations theoretically achievable in woodland swamps. In addition, it would appear that the presence of organic material is of limited significance since mortality at Point A was demonstrated in jars containing leaf-litter. A measurable level of Abate was found only at Station 4a where 0.4 ppb was recorded. However, spray drift occurred to a distance of at least 200 feet at all stations and, in the case of Station 4a, probably extended to a much greater distance. It is unlikely that aerial application of liquid insecticides can be undertaken with greater control over drift, since special efforts were made throughout this program to restrict spraying to periods with the best possible weather conditions.

Concentrations of Abate detected in jars at Point E were all substantially below the calculated level of 120 ppb. The highest concentration recorded immediately after spraying was 14 ppb at Station 2 while the lowest was 0.4 ppb at Station 4a. Nonetheless 100% mortality of larvae occurred in all cases over the succeeding 24-hour periods regardless of the presence or absence of leaf-litter. After 24-hours,

Abate concentrations had fallen appreciably at Stations 2 and 4a, the level at Station 31 had dropped slightly, while an increase was noted at Station 24 probably due to a high initial concentration differential between the two jars. Interference from animals precluded the 24-hour sampling at Station 12.

Adsorption onto organic litter was quite rapid as evinced by 24-hour concentration factors at Stations 12 and 31 which were, respectively, 80 and 1670 times the water residues.

Concentrations of Abate in Swamps

Table 4 shows Abate concentrations recorded in the swamps adjacent to Point E immediately after spraying, and at 24, 48 and 96 hours, and finally after 1 week. The highest initial concentration was detected at Station 24 (25 ppb) while the lowest, as with the jars, was at Station 4a (0.4 ppb). Initial values were all less than the calculated concentration of 60 ppb based on a 12-inch water depth, although actual depths were generally well below this level. Over the succeeding week, concentrations in the swamps at all stations fell gradually to levels at or below the detection limit of 0.1 ppb. It is likely that much of the chemical became adsorbed onto organic material since, after 48 hours, values for leaf litter at Stations 2, 4a and 12 were 750, 330 and 50 ppb respectively, indicating concentration factors of 500 to 3300 times water residues. The persistence of Abate residues in sediments of woodland pools has not been evaluated at the present time but existing literature suggests that complete degradation of the parent compound is likely to occur within several weeks. However, very little is known or understood about the persistence or properties of Abate derivatives.

SUMMARY OF LARVICIDING EVALUATIONS

In view of the significance of identifying those factors most influential in governing the degree of control achieved, every effort was made to relate effectiveness to tree height, cover density, water depth and larval development. However, these attempts met with little success and it is concluded that daily climatic conditions, combined with several features of the swamp habitat, are likely responsible for the highly variable results obtained. Amongst the many influential features which collectively characterize individual woodland habitats, tree density is considered the single most important factor in limiting the success of aerial larviciding. The best evidence available for this theory stems from Plot 12, where excellent control was achieved throughout, and tree density was significantly less than in the majority of other plots treated.

Table 5 summarizes the entire larviciding program and shows the estimated degrees of control for the 39 stations evaluated. Aerial applications were rated satisfactory at approximately half of the stations while Abate capsules proved satisfactory at 3 of the 4 stations subjected to post-treatment checks. Granular Abate gave excellent control in one small plot and partial control in another while the effectiveness of Flit MLO, which is discussed in more detail in Appendix D, was dictated by the dosage rate employed. Generally poor control was noted in those plots located in proximity to the adult trapping routes where adult populations were assessed in 1970 and 1971.

The following points emerging from this study are worthy of emphasis:

1. Aerial applications of liquid larvicide to woodland swamps are unlikely to provide more than sporadic

TABLE 5: SUMMARY OF LARVICIDING PROGRAM - MARA TOWNSHIP 1971

	No. Plots Treated	Acreages Treated (Approx.)	No. Survey Stations Evaluated	Degree of Control (No. Stns.)			
				S	U ₁	U ₂	U ₃
Aerial Spraying (Abate 4E)	29	3835	25	12	5	3	5
Abate Capsule	6	<1	4	3	1		
Granular (Abate 2G)	6	<1	2	1	1		
Flit MLO	2	<1	2	1			1
Plots adjacent to Adult Trapping Area	3	N/A	5	1	1	1	2
Totals	46	3837	38	18	8	4	8

N/A Not applicable i.e. some plots extending a great distance from trapping area.

control of larvae except where tree density is minimal. Applications made after leaf break would be totally unsuccessful.

2. Water depth of temporary woodland swamps has little or no effect on the degree of control to be expected.
3. Considerable drifting of larvicide can be expected from aerial application, even under ideal weather conditions.
4. Quantities of Abate required to effectively treat woodland habitats from the air are excessive due to interference with spray descent caused by vegetation and wastage due to lateral drift and convection currents.
5. Abate residues in water do not persist at detectable levels for more than 1 week although considerable adsorption to sediments occurs. The long-term significance of sediment residues, either of parent compound or derivative, remain undefined at the present time.
6. Due to wide variations in the timing of larval development in different plots and the prevalence of unsuitable flying conditions over much of the spring period, it is considered unlikely that large-scale larviciding programs in southern Ontario can be scheduled so that optimum spraying conditions are observed at all times. The net effect of these obstacles may frequently be that substantial acreages of larval habitat cannot be treated prior to the onset of pupation.

SECTION III
QUESTIONNAIRE

SECTION III

QUESTIONNAIRE

In late August, 1972, a brief questionnaire was distributed to 1,477 property owners in Mara Township so that residents would have the opportunity to voice opinions as to the severity of the mosquito problem and the effectiveness of control programs undertaken to date. A copy of the questionnaire and covering letter will be found in Appendix H.

All residents of the township whose assessments included contributions towards the cost of control operations had a questionnaire delivered to their premises. The majority of these people are seasonal residents and it is possible that a significant number did not receive the circular in time to meet the stipulated closing date for their return. However, all questionnaires received before October 20, 1972 were evaluated.

103 questionnaires were distributed to permanent residents, many of them members of the farming community, who had not been assessed for mosquito control since their properties fall outside the areas of prime concern with respect to relief from biting, i.e. shoreline recreational zone. However, it was felt that a selected number of permanent residents should be canvassed due to their often greater familiarity with local conditions and because, in some cases, portions of their property received direct applications of insecticide.

Results of Census

Of the 1,477 questionnaires distributed, 527 or 35.7% were returned. It is considered most unlikely that the

balance reflects the number of questionnaires not received by property owners, since all staff participating in the distribution reported that approximately half the residences were occupied at the time of delivery.

The replies were segregated into three categories, as follows:

- A) persons assessed for mosquito control,
- B) persons not assessed for mosquito control and
- c) persons assessed for mosquito control and owning residences within the Brechin Beach - Lagoon City area in which the adult trapping study was undertaken.

The percentage response for each category is listed below.

	A Assessed	B Not Assessed	A + B Total	C Brechin Beach
No. delivered	1374	103	1477	300
No. returned	493	34	527	131
% returned	35.9	33.0	35.7	43.7
% of total returned	93.5	6.5		

Score sheets were prepared for each category so that answers from individual questionnaires could be registered independently under coded headings. Code numbers corresponded to pre-determined responses covering all possible answers, positive or negative, for each of the eight questions. The 81 possible answers were grouped into 18 series, each series consisting of a number of positive answers and one negative answer so that, regardless of the manner in which a questionnaire was completed, 18 responses would be recorded from each questionnaire entered on the score sheet. A check mark under a negative response heading was used wherever a question was unanswered, the question was incorrectly answered or where a negative choice was made. In this way, it was possible to ensure that only clear,

decisive answers were included under positive headings and that all summaries and conclusions were derived from relevant, unambiguous responses.

The majority of respondents were seasonal residents of Mara Township (78%) although, in the unassessed category, almost all were permanent residents (94%). Forty percent of all replies were from residents of greater than 20 years standing while seventy-five percent were from those residing in Mara for more than 6 years.

Two questions were included on the severity of mosquito biting in past years. The first required respondents to list the following periods in order of severity to the best of their ability:

prior	to 1950
1951	to 1960
1961	to 1967
1968	to 1972

The second question focused attention on the last period, during which mosquito control programs had been undertaken, and required persons answering the questionnaire to list the years from 1967 to 1972 in order of biting severity. The underlying rationale for these questions was that, if improvements had been evident to residents of the township, the most recent period, and those years within this period during which larviciding was undertaken, would be rated low on the severity scale by a significant proportion of respondents.

The answers submitted to both questions gave no indication that particular periods or years were exceptional with respect to high or low intensities of biting. The large majority adopted one of two approaches to answering these questions, either indicating that the problem has been getting steadily worse or that there has been progressive improvement over the past five years. These opposite opinions likely originate from the same general attitude which favours mosquito control, and which prompts

individual residents to support continued control operations either by indicating the need to suppress a gradually worsening situation or to maintain conditions which have obviously improved due to recent spraying. The findings were similar in each of the three categories, and as a result, it has not been possible to confirm or refute the conclusions on spraying efficacy derived from the field studies by utilizing data from the questionnaires.

May and June were considered the worst months for mosquitos, followed by July and August with September having the lowest nuisance level. The ratings for each period were 69%, 30% and 1% of the total, respectively. Corresponding ratings for the Brechin Beach - Lagoon City sector were 58%, 42% and zero which implies that the difference between late spring and mid-summer conditions is less marked in the latter area than elsewhere in the township. More than half the respondents felt that sundown is the worst time of day for mosquitos while the balance felt that sundown and early morning are equally severe. Both these findings are in agreement with the results of the adult trapping study. The intensity of biting during the spring period is, however, not related to a greater abundance of mosquitos but rather to a predominance of females in comparison to later months.

Outdoor, land-based activities are most frequently affected by the presence of mosquitos with water-based activities next in line (89% and 36% being effected in each case). Indoor and business activities are not seriously influenced although permanent residents in category 'B', many of them members of the farming community, were understandably more concerned about the impact on business than seasonal residents (18% as opposed to 6%).

In response to the question on the severity of the mosquito situation in Mara Township as compared to other rural areas of Ontario, 46% felt that conditions are more severe than in other areas they had visited, 26% felt they are the same and 28% considered them less severe.

Corresponding percentages for residents of the Brechin Beach - Lagoon City sector were 67%, 14% and 19% respectively which suggests that the problem in this area is significantly greater than average for the township. This possibility is enforced by the fact that some of the major swamplands and heaviest larval infestations are located in proximity to the Brechin Beach area. However, it is of interest to note that less than half of all respondents felt that the mosquito problem in Mara township is unusually severe whereas the great majority (94%) elected for some form of control program.

Larviciding and adulticiding were considered necessary by 51% of the residents surveyed; 14% preferred to see an alternative non-chemical method of control, while a further 20% supported control but did not specify any particular control method. A complete breakdown of responses within the three categories is given below:

<u>Form of Control</u>	<u>A</u>	<u>B</u>	<u>Total</u>	<u>C</u>
Larvae and adults	52%	30%	51%	44%
Larvae alone	6%	18%	7%	7%
Adults alone	2%	4%	1%	1%
Uncertain	21%	18%	21%	25%
Some alternative	12%	27%	14%	13%
None	7%	3%	6%	10%

In general, the pattern of response was similar in all categories although the proportion of unassessed residents (mainly local) in favour of non-chemical control was more than twice that of the assessed residents (27% as opposed to 12%). The proportion of negative responses was greatest from the Brechin Beach - Lagoon City sector (10%) while the least negative responses came from those in the unassessed category (3%).

The final question related to the amount of financial support which residents would be prepared to give annually towards mosquito control operations. Taking all responses into account, 7% were prepared to contribute up to fifty dollars, 34% up to twenty dollars, 82% up to ten dollars and 18% were opposed to giving any financial support whatsoever. A complete breakdown of responses by category is given below:

	A	B	Total	C
Up to \$10	74%	73%	82%	77%
Up to \$20	21%	28%	34%	34%
Up to \$50	6%	11%	7%	7%
Zero	16%	17%	18%	23%

The results are similar for all categories and show that a standardized assessment fee of ten dollars is the maximum that residents would be prepared to pay each year for mosquito control in Mara Township.

Summary of Questionnaire Findings

1. Of 1477 questionnaires distributed to residents of Mara Township within the mosquito control zone only 527, or 36%, were completed and returned. This somewhat low response is not considered entirely a function of the number of residents receiving questionnaires.
2. Township residents were unable to identify any marked differences between years with and without larviciding programs but tended to support their requests for continued spraying by indicating a gradual worsening or improvement in the severity of biting over the past five years. As a result, it was not possible to confirm or refute the conclusions on spraying efficacy drawn from field studies by utilizing data from the questionnaires.

3. The severity of biting is greatest during the months of May and June although, in the Brechin Beach - Lagoon City sector, mid-summer conditions are somewhat worse than normal and not greatly different from the spring. Biting is considered most severe at sundown.
4. Less than half of all respondents felt that the mosquito problem at Mara Township was greater than at other areas they had visited, although the great majority (94%) elected for some form of control program.
5. Both larviciding and adulticiding operations were considered necessary by 51% of the respondents while 14% preferred to see some alternative to chemical methods of control.
6. The large majority of residents (82%) were prepared to contribute ten dollars annually to mosquito control, whereas 34% and 7% were prepared to contribute up to twenty dollars and fifty dollars respectively. A standardized assessment fee of ten dollars would therefore be the maximum which could be imposed with majority support from township residents.

GENERAL DISCUSSION

The three studies described in this report constitute the first major attempt to assess the need for, and feasibility of controlling mosquitos in a rural area of southern Ontario with techniques and procedures available to local authorities. The foremost consideration in all such programs is that government involvement is confined to the formulation and administration of regulations governing the use of insecticides required and the dissemination of advice concerning chemicals and field procedures. Organization and funding is in all cases the responsibility of the person or persons initiating the control program. In trying to identify some of the more obvious failures of the present system it is apparent that this lack of support for an undertaking which is at times both costly and complex is a prime factor responsible for inadequate planning and poor spraying practices.

Before discussing the implications of this situation and expanding on the technical problems relating to current control techniques, it is important to place the entire question of mosquito abatement for relief of nuisance conditions in proper perspective.

At the present time mosquito control in Ontario is not essential. Without it, the quality of life in most areas will not be affected by biting to any greater degree than it has for hundreds of years. Mosquitos, as with black flies, sand flies and other biting insects, are an integral part of our rural and wilderness environments and in choosing to inhabit or visit these areas the majority of people have been prepared to accept them as an inevitable, although undesirable feature of an otherwise valuable resource.

In some cases it becomes an economic necessity to alleviate biting problems in and around northern construction camps, mining and logging operations, but activities of this nature have been on a small scale, tightly controlled and undertaken by experienced personnel. It may be argued that economic incentives also exist for control programs in areas where tourism is the major source of revenue and outdoor activities are impaired at certain seasons by a high incidence of biting flies. However, there would seem to be little justification for such measures since visitors to our rural areas are voluntarily selecting the Ontario countryside for their recreational pursuits and should be prepared to accept the natural conditions as they exist, without the added luxury of a pest-free environment provided at the expense of local property holders.

No rational person would be opposed to the principle of controlling biting flies for any purpose if it could be clearly shown that the techniques involved had no lasting adverse effects on the environment. In certain areas mosquito populations may be substantially reduced by eliminating larval habitats through swamp drainage, ditch clearance and the removal of miscellaneous small reservoirs containing rainwater. This type of control which is not dependent on chemical insecticides, avoids all possibility of physiological damage to terrestrial and aquatic forms of life. Unfortunately, such measures are seldom entirely adequate and must be supplemented by chemical spraying of the remaining wet areas. In the majority of rural areas in Ontario reduction of larval habitat is not possible due to the inaccessibility of swamp-lands and the prevalence of thin organic soils overlying impervious bedrock. This reliance on chemical control methods renders it important that the public are fully acquainted with the limitations and potential hazards associated with insecticide use, so that they may carefully consider these factors

before requesting local authorities to initiate abatement programs. In addition, improved knowledge of the problems surrounding mosquito control would create a better understanding of the rationale underlying the recent policies and restrictions imposed by the Ministry.

Many persons not directly involved with the biological sciences suffer from the misconception that biting fly control with insecticides is now an established, proven procedure employed by authorities at the local government level in many nations of the world. This impression has undoubtedly arisen from the great deal of publicity given to mosquito control programs undertaken in past years to combat infectious diseases on a world-wide basis. The success of these operations was almost entirely due to the heavy and continuous use of chlorinated hydrocarbon insecticides, particularly DDT. Use of these materials was not known to constitute any undue threat to man or his environment and was the only possible solution to effective control of many serious health problems. As the effectiveness of the chemicals became more widely known and increased quantities were manufactured, use was rapidly extended to the relief of nuisance conditions in populated areas of the more developed countries. However, it gradually became evident that certain species of mosquito were capable of developing resistance to various chlorinated hydrocarbons and new compounds had to be used with increasing frequency to maintain the desired level of control. Then, in the early 1960's fish and wildlife experts became concerned by the accumulation of insecticide residues in many animals and the often disastrous consequences to wildlife which resulted from intensive spraying. Soon afterward the use of many chlorinated hydrocarbons was restricted for all but essential uses and a new class of insecticides, the organophosphorous compounds, succeeded the latter for mosquito control purposes in many areas. Some of the most important differences between the two classes of

compound have already been mentioned in the Introduction to this report.

It is now known that the use of organophosphorous insecticides does not necessarily overcome the problem of resistance (Brown 1968 and 1969). For example, in the Central Valley of California, the pasture mosquito which has tremendous reproductive potential became resistant to DDT within three years. Garcia (1972) completes the story as follows:

"Following resistance to DDT, a series of different chemicals was applied for control. Malathion, ethyl parathion and methyl parathion were used extensively during the 1950's, but complete resistance was developed to all these compounds by the early 1960's. Fenthion was then introduced and gave adequate control until its failure in 1968. Other chemicals, such as Dursban, were employed, but they too were effective for only a short time. The situation is truly in a crisis state as far as chemical control of mosquitos is concerned. The remarks of one mosquito abatement manager at a recent mosquito control meeting summed the situation up: - In many counties of the state, chemical sprays are no longer effective at safe, legal, economical rates. After 25 years of continuous spraying the mosquitos have become immune or multi-resistant to all common public health mosquitocides including malathion, parathion, E.P.M., fenthion, abate, vaponal, dibrom, dursban and others."

At present, the situation with respect to the pasture mosquito in California is an extreme example of resistance in mosquitos. Brown indicates that resistance in mosquitos has

a genetic foundation and implies that it is presently impossible to predict the development of resistance to a given insecticide since a single gene is involved and is not always present even within a species. Four members of the genus Aedes are known to have developed resistance to organophosphorous compounds but these do not include species common to Ontario. However, it seems likely that resistance will develop progressively in other species and in more areas as the frequency and intensity of chemical use become greater. An even more disconcerting aspect of this phenomenon is that cross-resistance can also occur, even between different classes of insecticide, so that switching to alternate compounds may provide no improvement in control whatsoever. Regardless of the fact that many of these findings lack relevance to Ontario at this time, the principles are firmly established and should act as a warning to avoid pesticide use unless absolutely essential. A recent brief prepared for the Entomological Society of Canada (1970) includes a point by point analysis of the facts and philosophies surrounding pesticide use in Canada. Inherent throughout the brief is that present levels of pesticide use will remain essential if present standards of health, comfort and pest control are to be maintained, but it emphasizes the importance of avoiding escalation of such uses, as follows: Item 4 (g) 'Pesticides should be used only when needed, and in the minimal quantities required to protect the resource'.

Another possible outcome of continuous pesticide spraying against mosquitos is that such treatments can bring about much worse infestation than no treatment at all. It appears that pesticides may knock out the mosquito's natural enemies more readily than the insect itself. A situation of this type has recently been reported from the California rice fields by the U.S. Department of Agriculture (Anon 1972).

Although further accounts of such incidents could not be traced in the literature, it seems likely that predator mortality has been largely overlooked as one factor responsible for poor results when combatting mosquitos with chemical sprays. A large number of animal groups are known to include predators of mosquitos, particularly the Hemiptera (bugs) and Coleoptera (beetles) (Bates 1949). There is information to suggest that both groups may be quite sensitive to Abate larvicide with the backswimmer (*Notonecta* sp. Hemiptera) being highly susceptible under field spraying conditions (Fales et al. 1968). The principle of population 'rebound' following chemical biting fly control may be well illustrated by the dramatic increase in blackflies which followed early spraying of DDT in Canada and which caused severe mortality of predaceous caddis larvae and stonefly nymphs in addition to blackfly larvae (Davies 1950 and Muirhead - Thomson 1971).

It seems clear from the scientific findings discussed above that Ontario is presently in an enviable position by comparison to other regions with a long history of mosquito control activities. The most important lesson to be learned from these experiences is that mosquito control, much like other attempts at controlling animal pests, cannot be obtained without cost to man and his environment. It should be evident that any decision to initiate large-scale spray programs carries with it an immense responsibility since the eventual outcome may indeed be regrettable. Eradication of these prolific insects is quite impossible and even the best control may provide little more than temporary relief from biting. Annual spraying, once implemented would have to be continued indefinitely at great financial cost and with no prospect of increasing return if the level of control is to be maintained. In some cases, progressively greater quantities of pesticide will be needed to maintain control, resistance may develop and new chemicals may be required with increasing frequency. Experience suggests that

the long-term environmental consequence cannot be predicted even though the emphasis is on more specific, short-lived insecticides. It would appear unquestionable that the only prudent course of action is to avoid chemical control of mosquitos wherever possible and to encourage the development of alternative measures to meet the public demand, if and when it occurs.

The need for education with respect to the problem of biting fly abatement, and for advice and assistance with non-chemical methods of control, could be satisfied by establishing a special unit within the Ministry of the Environment to provide such services on a permanent basis. This group of trained personnel could also explore the potential of new control techniques, including biological control and the use of sex attractants, although emphasis should be placed on permanent methods of control at all times. Continuing assessment of the problem within the province might be undertaken to determine the relative severity and economic importance of biting in different areas. Scientific staff, having entomological expertise, would review the entire question of biting flies and their control in Ontario and have responsibility for developing guidelines for all future activities in this area. An important aspect of their work would be to recommend improved regulations governing the uses of adulticiding chemicals and the mist-blowers and thermal foggers necessary for their application. It would also be important to identify those circumstances under which larvicides might be legitimately employed, such as in the event of health problems or for limited use in and around private property, mining, logging and northern construction sites.

The studies at Mara Township, documented in this report, carry the review of mosquito control activities a step further to problems encountered in the field situation and would more logically apply to a region already committed to abatement programs. Nonetheless, it is felt that in describing the technical and

administrative difficulties which currently exist in this province the arguments against chemical mosquito control may be substantially enforced.

Both field observations and the results of the adult trapping study support the belief that the 1971 larviciding at Mara Township was unsuccessful. This came about despite the extensive field surveying conducted by Ministry personnel to ensure that all infested habitats were identified and sprayed under the best conditions attainable at the time. Without Ministry support for this phase of the program it is likely that the results would have been even less satisfactory. The township authority provided all the assistance at its disposal and was most co-operative throughout but could not be expected to undertake comparable field surveys in the absence of outside help and experience. There is no reason to believe that other local authorities or organizations are presently any better equipped for such investigations. The necessity for pre-operational surveys is well established and strongly supported by those agencies involved with mosquito control. A publication released by the Alberta Department of Agriculture providing advice on control procedures, states - "Precise location of mosquito larval breeding sites by intensive surveys is a prerequisite to safe and efficient control", (Publication 673-2, 1972). There is little doubt that this work will not be undertaken efficiently in the absence of an established agency with the resources and authority to organize and support it.

It has been estimated that approximately 700 man-hours were devoted to pre-operational field surveying in Mara Township during the spring of 1971. At a conservative estimate of \$2.50 per hour, expenses for labour, not including vehicle costs, would have been in the region of \$1,750.

Perhaps the major reason for the poor quality of control achieved was the interference with spray descent due to the presence of vegetation throughout most of the areas treated. It has already been stated that much greater interference would be encountered following leaf-break, and therefore, that liquid sprays could not be applied except in the early spring. The use of granular formulations would largely overcome these difficulties but, as will be seen below, would increase the cost of chemical more than four-fold.

	Cost	Quantity Per Acre	Cost Per Acre
Abate 4e	\$0.28 per fl. oz.	1.5 fl. ozs.	\$0.42
Abate 2G - granular	\$0.38 per lb.	5 lbs.	\$1.90

* retail prices, courtesy of Cyanamid of Canada Limited.

Granular formulations of larvicide have a further advantage over liquids in that drift is minimized and the material can be applied under any weather conditions suitable for flying. However, the extent to which uniform distribution of granules can be achieved by aerial application is not known at present and would have to be investigated carefully before this method could be recommended. Furthermore, the greater weight of material required per acre would reduce the coverage per payload and likely increase the application costs. This consideration has not been applied to the cost estimates which will be discussed shortly. A serious drawback with granular formulations is that where small pools alternate with patches of dry ground, granules may remain intact for considerable periods and could prove attractive as grit or food items for birds. Gaines (1967) showed significant mortality amongst

chicks and ducklings receiving dietary doses of Abate from 25 to 50 mg/kg/day for five days while 10 mg/kg/day produced temporary symptoms of toxicity. Assuming 125 mg Abate constitutes a lethal dose to a 1 kilogram bird, 12.5 mg would therefore be toxic to a small bird of 100 grams body weight. Since a single gram of granular Abate 2G contains 20 mg of active material there would seem to be ample cause for concern over the possibility of ingestion of Abate granules by ground-feeding, woodland birds. At the present time alternative larvicides are not available in granular formulations although Dursban, which has a similar toxicity towards birds, may soon be marketed in this form. The margin of safety would not appear to be very great and further studies, particularly on the palatability of Abate granules to birds, are essential before the safety of woodland species can be assured. It is worth recording here that several residents of Mara Township have already expressed concern to the Ministry that bird populations seem to have diminished in recent years, although there is no direct evidence to link this situation with spraying operations. It must be emphasized that the onus for establishing the complete safety of pesticides rests with the manufacturers.

It is of interest to calculate the overall annual cost of applying Abate granular to an acreage equivalent to that sprayed in 1971, with two appropriately timed treatments, and including costs of spraying and surveying based on the 1971 estimates:

Cost of Chemical (2x3800x\$1.90).....	\$14,440.
Spraying Costs (2x\$3,290).....	6,580.
Field Spraying (\$1,750. + $\frac{*1,750}{2}$)	2,625.
	\$23,645.

* 2nd survey would require only half the labour.

This annual cost is equivalent to an annual contribution of around \$16.00 from each of 1500 township residents. It will be recalled that the majority of residents surveyed by questionnaire voted to contribute no more than \$10.00 per year. In looking for alternatives to chemical control, it would seem appropriate to suggest that advice be obtained from a competent drainage engineer as to the possibilities of improving land drainage in certain parts of the township, since the above figures would undoubtedly go a long way to affecting such improvements if they can be shown practicable and ecologically sound.

A number of extensive wetlands occur in Mara Township close to the shore of Lake Simcoe and adjacent to developed areas. These wetlands are naturally subject to poor drainage since they are generally situated at low elevations relative to the water level in the lake. Spring and summer lake levels fluctuate about 6 inches between years so that certain years will tend to be somewhat worse than others with respect to land drainage. Field observations by Ministry personnel indicate that a number of man-made features may accentuate the poor drainage conditions. Along much of the township shoreline a road runs parallel to the lakeshore and directly behind a row of summer cottages. On a number of occasions it was observed that culverts were blocked by organic debris and weeds and that drainage ditches feeding them were partially or totally occluded. In addition, the number and spacing of these culverts would appear to prevent adequate drainage of the interior. It is felt that a number of carefully planned modifications to the drainage system might eliminate or reduce the extent of wetlands providing larval habitat. Under special circumstances, where severely infested pools occur in woodlands close to residences, consideration might be given to channeling or piping the water from the woods to the culverts communicating with the lake. Particular importance must be attached to any measures which might help to reduce mosquito breeding grounds since control

achieved in this way will be permanent, unlike the purely temporary control attainable through the use of pesticides.

A further alternative to pesticides which warrants consideration is the use of light traps which attract and kill mosquitos and other flying insects. Commercially available traps are not effective over a wide area but are said to give satisfactory results in the immediate vicinity of back yards, patios and verandas. They are electrically operated and apart from the light source have various mechanisms for eliminating insects including suction and electrified screens. Costs vary from around \$50.00 to more than \$200.00 for domestic varieties although larger, more expensive models are available for industrial purposes. A number of local pest control agencies market light traps and one concern will shortly sell an \$80.00 trap with a guaranteed lamp life of 6000 hours and inexpensive replacement cost. One obvious drawback of these devices is that ordinary lights may interfere with their attracting ability and they must therefore be installed away from other illumination. However, when strategically placed they may provide good protection from mosquitos in the vicinity of cottages after sundown, which has been shown to be the worst time of day for biting.

Personal protection from mosquitos and other biting insects may be effectively accomplished through the use of repellents. A number of products are now available in the form of liquids, creams and aerosol sprays and, providing they are used frequently will prevent biting indefinitely.

Small pools of stagnant water situated on private property may contain mosquito larvae during the spring and early summer. Where these cannot be permanently drained and do not communicate directly with an open watercourse, it is legitimate for property owners to apply an approved larvicide to control the larvae. Abate capsules, marketed

in small quantities, and effective at the rate of 1 capsule per 1000 sq. ft. are ideal for this purpose since they offer the ultimate in simplicity of handling and safety to the operator, and avoid all chances of drift. However, other larvicides are available for this purpose and may be equally effective. Larviciding of small water bodies on private property may be particularly worthwhile where heavy infestations occur in proximity to dwellings. However, they must be used only at recommended rates and where larvae are seen to be present and cannot be recommended on properties where large swamps with heavy larval infestations occur on adjacent land.

An important objective of the questionnaire survey was to determine more precisely the extent of public concern over mosquitos in Mara Township. In view of the poor response, it could be argued that a large segment of the population is somewhat disinterested in mosquito control, a situation which was totally unforeseen in view of repeated requests to the Ministry for control authorization. However, it is well recognized that door-to-door questionnaires rarely elicit better than a 50% response regardless of the issue concerned and, since there are many possible explanations for this, it may be erroneous to assume that a better return would be expected under the present conditions. Whatever the true situation may be, the facts remain that only 490 people out of a possible 1477, or 33%, gave a positive indication that they were in favour of control. Moreover, the depth of concern within this group does not seem particularly great since the majority were not prepared to lend more financial support than has been required up till this point. An interesting aspect of the responses concerning the severity of biting in Mara compared to other areas, was that over half indicated the problem to be no more severe than in other areas with which they were familiar. Contrasted with the almost

unanimous vote for mosquito control it would appear that approximately half the respondents would be content to see such operations extended to all areas where biting occurs. This would support the contention that there is an urgent need for education with respect to the facts and uncertainties surrounding biting flies and their control in Ontario.

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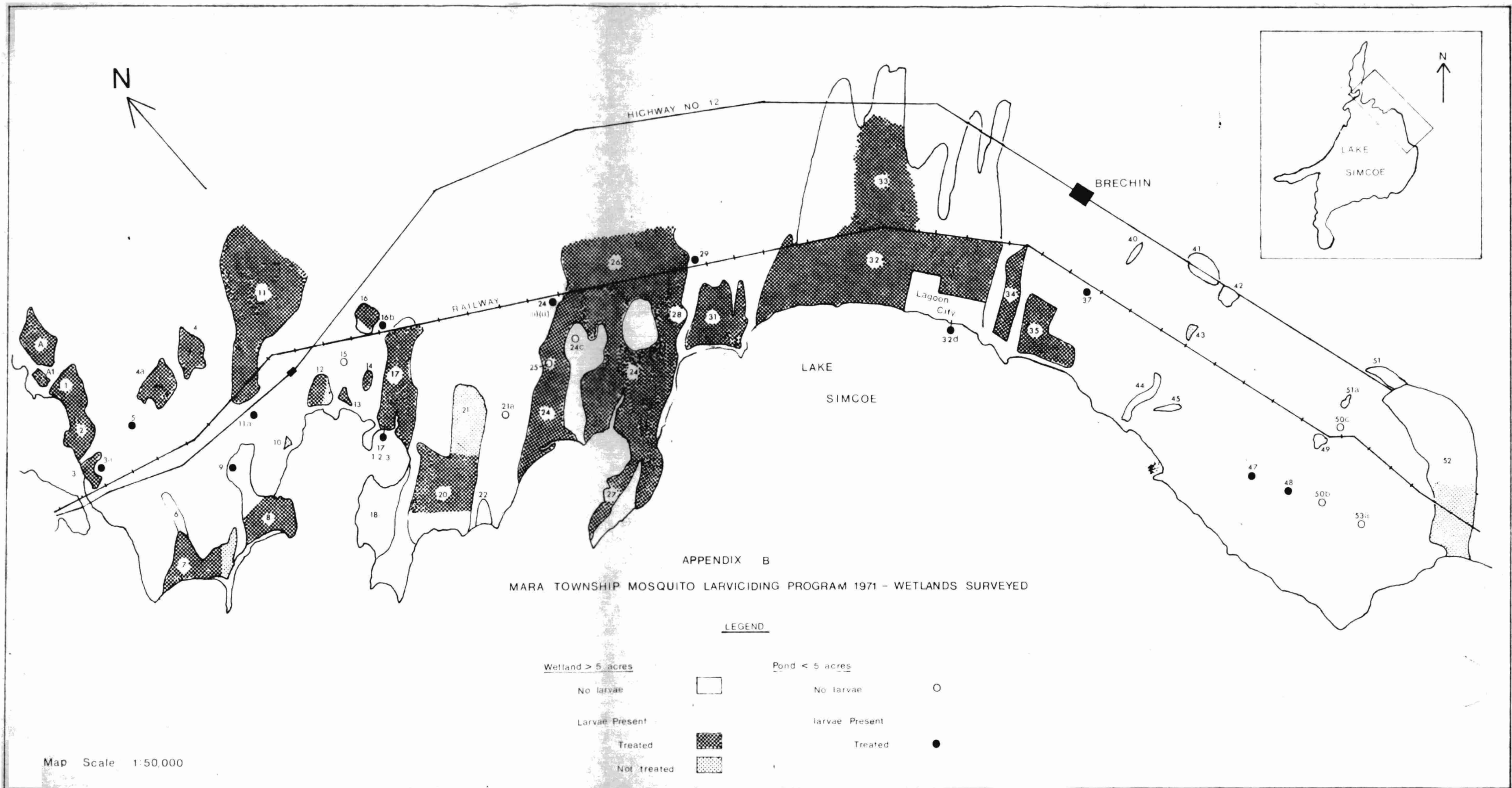
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APPENDIX A:

MOSQUITO TRAPPING DATA - MARA TOWNSHIP - JUNE TO OCTOBER, 1970-1971

Week No.	Trapping Date		Sundown Times		Median Evening Temp °C		Inches Rain Previous 2 wks.		No. Males Captured		No. Females Captured		Total Adults Captured	
	1970	1971	1970	1971	1970	1971	1970	1971	1970	1971	1970	1971	1970	1971
1	9/6	10/6	8:57	8:58	22.5	18.0	0.39	0.31	129	227	290	58	419	285
2	18/6	17/6	9:02	9:01	21.5	23.0	0.49	0.34	0	27	3	27	3	54
3	25/6	24/6	9:03	9:03	15.25	19.0	1.29	1.37	4	9	15	82	19	91
4	2/7	30/6	9:02	9:03	22.0	26.25	1.75	2.69	1	1	74	18	75	19
5	9/7	8/7	9:01	9:01	25.25	22.5	2.48	2.84	13	2	93	92	106	94
6	16/7	15/7	8:56	8:58	19.25	21.5	3.19	1.69	2	18	27	71	29	89
7	23/7	22/7	8:52	8:52	22.0	20.0	2.87	1.30	10	4	118	101	128	105
8	30/7	29/7	8:43	8:45	25.75	17.25	1.46	2.01	71	15	131	64	202	79
9	6/8	5/8	8:36	8:36	23.0	20.5	0.42	1.18	48	11	138	62	186	73
10	13/8	12/8	8:24	8:27	25.0	22.75	1.29	0.12	12	1	64	0	76	1
11	20/8	19/8	8:16	8:15	21.0	24.5	1.46	0.25	0	31	14	6	14	37
12	27/8	26/8	8:03	8:04	20.25	18.5	0.34	1.47	32	196	11	53	43	249
13	3/9	2/9	7:51	7:52	19.75	21.5	1.78	2.01	3	43	0	38	3	81
14	10/9	9/9	7:37	7:39	16.75	18.0	1.78	0.69	1	255	0	212	1	467
15	17/9	16/9	7:26	7:26	14.0	14.75	1.38	0.38	94	308	51	23	145	331
16	24/9	23/9	7:11	7:13	26.0	15.75	2.69	1.03	1149	1	63	0	1212	1
17	1/10	30/9	7:00	7:00	12.25	18.5	1.58	0.67	42	73	12	48	54	121
18	8/10	7/10	6:45	6:47	20.75	9.75	0.82	0.39	193	0	192	0	385	0
19	15/10	14/10	6:31	6:35	9.25	14.75	1.69	1.35	1	16	6	2	7	18
TOTALS									1805	1238	1302	957	3107	2195



APPENDIX C

INSTRUCTIONS FOR MOSQUITO LARVAL SURVEY
MARA TOWNSHIP 1971

- Select an area for sampling which is as representative as possible of the whole plot or of a major cover type within a plot. Each major cover type within a plot should be surveyed if possible.
- The sampling area should comprise an area of approximately 1000 sq. ft.
- Run the dip net along the surface of the bottom debris for about 6 feet. Two dips should be sufficient if the sample area is homogeneous. Up to 10 dips should be made to confirm absence.
- Count the larvae retained.
- Note locations of dense larval clusters for post application assessments of effectiveness.
- Retain up to 20 of the larvae collected, in a 1 oz. vial and preserve in 70% alcohol.
- Locate sampling location on mosquito map.
- Indicate percent water coverage of area.
- Give maximum and minimum (range) of water depths.
- Water Temperature
 - Take at 4 inches beneath surface or where there is less than 4 inches of water, take at mid depth.
 - Record maximum and minimum temperatures, at least three locations per station.
- During repeat surveys check for new habitat and note other changes since last visit.

APPENDIX D

A SHORT FIELD EVALUATION OF THE MOSQUITO
LARVICIDE FLIT MLO. MAY 1971

In May 1971, the mosquito larvicide FLIT MLO was applied by back-pack sprayer to two small ponds in Mara Township, Southern Ontario. These treatments were supplemental to a large-scale investigation into the practicability of controlling mosquitoes by a single aerial spray of the organophosphorous compound, Abate 4E; As such, this evaluation of FLIT was introductory in nature and no attempt was made to determine optimum treatment rates under different habitat conditions or the precise effects on mosquito larvae and non-target aquatic invertebrates. Pond A was treated at a rate of 5 gallons product per acre while Pond B was treated at 2 gallons product per acre. These dosages correspond to the limits of the range suggested by the manufacturer. Full descriptions of the two ponds are given in Table 1. Both ponds were heavily infested with second and third instar larvae at the time of treatment.

Prior to spraying collections of pond fauna, including mosquito larvae, were made by running a triangular dip net for a distance of 6 feet, midway between surface and bottom, at three randomly selected locations. This procedure was repeated 24 hours after spraying and again at 72 hours, but a problem with the preservative caused the loss of the latter samples before they could be examined.

Table 2 shows results of the pre-treatment and 24 hour dip net fauna counts. At the higher rate complete elimination of mosquito larvae and cladocerans was noted while a significant reduction of caddis larvae was also apparent. Visual checks of

the entire pond revealed a few surviving mosquito larvae but their numbers were insufficient to alter the conclusion that the 5 gallon/acre rate had been highly effective. At the lower rate a 77% reduction of mosquito larvae was recorded whereas cladocerans were eliminated. Visual checks conducted on subsequent days confirmed that significant numbers of mosquito larvae survived the 2 gal/acre treatment.

In summary, this study indicates that the optimum dosage rate of FLIT MLO for the control of mosquito larvae in shallow ponds with organically rich bottom sediments lies somewhere between 2 and 5 gallons per acre. However, even at the lowest rate considerable reduction of cladoceran populations may be expected; further work would be necessary to determine the significance of such effects and the time required for repopulation. At the higher rates certain other invertebrates, notably caddis larvae, may also be affected.

Generally speaking, the control of mosquito larvae over small areas cannot be recommended since no significant alleviation from biting can be expected unless all breeding sites within flying distance of the control zone are treated. The high cost of FLIT MLO (\$1.35 per gallon in 1971) renders it uneconomical for extensive use at the present time. Furthermore, this chemical does not appear to offer any particular advantages in terms of efficacy or safety when compared to less costly materials currently available.

TABLE 1: DESCRIPTION OF PONDS UTILIZED FOR EVALUATION
 OF FLIT MLO

	Plot 'A'	Plot 'B'
Bottom Type	Grass and leaf litter	Grass and leaf litter
Cover Type	Willow scrub	Willow scrub
Cover Density	Heavy but sporadic	Heavy but sporadic
Ave. Temperature (pre-treatment)	23°C	22°C
Ave. Depth (pre-treatment)	5"	13"
Surface Area	3000 sq. ft.	2000 sq. ft.
Application Rate (gal/acre)	5 gal/acre	2 gal/acre

TABLE 2: SUMMARY OF NETTING SURVEY RESULTS, FLIT EVALUATION - MARA TOWNSHIP 1971

Pond Treated	Survey Date	Mosquito Larvae No.	Ave.Length (mm)	Amphi-poda	Anura	Clado-cera	Coleop-tera	Gastro-poda	Tricho-ptera	Union-idae
A	May 10 (pre-spray)	2238	10	3	2	120	0	0	11	0
	May 11 (24 hour post spray)	0	-	3	0	0	0	1	1	4
B	May 10 (pre-spray)	78	10	10	0	102	1	1	2	0
	May 11 (24 hour post spray)	10	11	12	6	1	1	0	5	0

APPENDIX E

METHODS FOR THE EVALUATION OF MOSQUITO LARVICIDING

1. Select 6 stations with the following characteristics:
 - 1) Light cover; small water volume.
 - 2) Light cover; large water volume.
 - 3) Moderate cover; small water volume.
 - 4) Moderate cover; large water volume.
 - 5) Dense cover; small water volume.
 - 6) Dense cover; large water volume.
2. At each of the 6 stations establish 5 sample points at 100' intervals along a transect which is at right-angles to the periphery of the plot; sample points to be designated as follows:
 - A) 200' outside plot.
 - B) 100' outside plot.
 - C) On periphery of plot.
 - D) 100' inside plot.
 - E) 200' inside plot.
3. Glass peanut butter jars (40 oz.) will be placed at each sample point in accordance with the table below:

Label Code	R/S/C	R/S/LL	R/S/W	R/S/T = 0
Water - 1 litre	X	X	X	X
Litter - handful	X	X		
Larvae - 10	X	X	X	

Sample Point	No. Jars (Covered)	No. Jars (Open)	No. Jars (Open)	No. Jars (Open)
A	1	1		2
B	1	1		
C	1	1	1	
D	1	1	1	
E	1	1	1	2

4. Before spraying the following samples should be taken from Sample Point E.
 - 2 x 32 oz. bottles of water
 - 1 x 1 lb. leaf litter from swamp bottom.
5. After spraying, activities will follow the schedule given at each of the following 6 stations.

Appendix E - Cont'd.....

	Immediately after spraying	After 24 hours	After 48 hours	After 96 hours	After 1 week
A	Pour both R/S/T = 0 jars into bottles.	Count dead larvae in jars.			
B		Count dead larvae in jars.			
C		Count dead larvae in jars			
D		Count dead larvae in jars and estimate swamp control.	Estimate control in swamp.	Estimate control in swamp.	Estimate control in swamp.
E	Pour both R/S/T = 0 jars into bottles and two more with swamp water, label R/S/T = 0/s	Count dead larvae in jars. Estimate control in swamp. Fill 2 bottles with swamp water, label R/S/T = 24 Pour R/S/LL and R/S/W H2O into bottles, retain R/S/LL litter.	Estimate control in swamp. Fill 2 bottles with swamp water, label R/S/T = 48	Estimate control in swamp. Fill 2 bottles with swamp water, label R/S/T = 96	Estimate control in swamp. Fill 2 bottles with swamp water, label R/S/T = 1 wk.

R = Station No.

S = Sampling Point Code

N.B. In setting up peanut butter jars, those at sampling stations
C, D and E should be three-quarters submerged in water.

APPENDIX F

ANALYTICAL TECHNIQUE EMPLOYED FOR ABATE ANALYSES BY THE PROVINCIAL PESTICIDE RESIDUE TESTING LABORATORY

A. WATER

One litre of water was partitioned by shaking vigorously for 60 seconds with 2 x 100 ml portions of dichloromethane. The dichloromethane extracts were dried by passage through anhydrous sodium sulphate and concentrated just to dryness with a rotary vacuum at 45°F. The residue was re-dissolved in 5.00 ml acetone and Gas chromatographic analysis proceeded without further cleanup.

B. PLANT TISSUE

Fifty gm. tissue were blended with 250 ml 2:1 (v/v) acetonitrile water for 5 minutes at high speed, filtered through a glass-sintered funnel and 100 gm of the filtrate (equivalent to a 20 gm sample) were collected. The filtrate was transferred to a separatory funnel and partitioned with 10 ml dichloromethane by shaking vigorously for 60 seconds. The phases were allowed to separate, 400 ml of 2% aqueous sodium chloride solution were added and the mixture shaken for 30 seconds. The dichloromethane mixture was drained through anhydrous sodium sulphate in order to remove water, concentrated just to dryness with rotary vacuum at 45°F and the residue re-dissolved in 2.00 ml acetone. Gas chromatography examination was undertaken without further cleanup.

Gas Chromatography

Column: 12" x 1/8" o.d. (glass or stainless steel) packed with 5% XE-60 on 80/100 mesh Chromosorb W.

Carrier gas: helium at ca 100 ml/min

Inlet temperature: 250°F

Column temperature: 240°F

Detection involved one of two methods;

a) flame photometric or b) alkali flame ionization

Appendix F - Cont'd.....

a) Flame photometric - phosphorus mode

gas flows: H_2 - 150 ml/min

air - 40 ml/min

O_2 - 20 ml/min

detector temperature - $250^{\circ}F$

b) Alkali flame ionization - rubidium sulphate flame tip

gas flows: H_2 - 38 ml/min

air - 230 ml/min

detector temperature - $280^{\circ}F$

Daily conditioning of the gas chromatography column was undertaken in order to achieve reproducible responses. This was accomplished by repeatedly injecting Abate standards until peak heights were reproducible. Analysis of samples was carried out by making alternate injections of sample and Abate standard.

APPENDIX G

FIELD SURVEY DATA - MARA TOWNSHIP SPRING 1971

LEGEND

Degree of Larval Control

S - Satisfactory
U₁) Unsatisfactory - in
U₂) - order of reduced
U₃) control.

Survey Number

1 - Conducted within the period
of April 20-22 inclusive
2 - Conducted within the period
of May 3-4 inclusive
3 - Conducted within the period
of May 6-13 inclusive

Larval Abundance

abs - absent
pr - present
pl - plentiful
abu - abundant

Treated Method

A - Aerial spray, Abate 4-E
C - Manual, Abate capsule
G - Manual, Abate 2-G granular
F - Manual spray, Flit MLO

^a Monitoring Station

APPENDIX G

FIELD SURVEY DATA - MARA TOWNSHIP SPRING 1971

Survey Station No.	Plot Acreage Treated (Approx)	Ave. Tree Height (ft)	Average Water Depth (in.)			Ave.Temp. (°C)			Larval Abundance			Ave.Size (mm)			Treatment Date	Treatment Method	Degree of Larval Control
			Survey No.			Survey No.			Survey No.			Survey No.					
			1	2	3	1	2	3	1	2	3	1	2	3			
OPEN																	
3a	<1		6	6	6	13	16		pr	pr	pl	3	5	6	6/5	C	S
9	<1			20	12			20		pr	abu		6	9	9/5	G	U ₁
11a	<1			4	4			13		pr	pr		5		6/5	C	U ₁
17(1)	<1										pl			7	12/5	C	
17(2)	<1										pl			7	12/5	C	S
17(3)	<1										abu			7	13/5	C	
28	13										abu			7	13/5	A	
29	<1			8	6		11	20		pl	abu		5	7	10/5	G	
LIGHT COVER																	
^a 12	25	30	0	3			16		abs	abu			6		7/5	A	S
16b	<1			4			19			abu			7		5/5	C	S
24(i)	<1				5			23			abu			9	10/5	F	S
24(ii)	<1				13			22			abu			9	10/5	F	U ₃
26	220	35	13	10		7	12		pr	pl		3	4		9/5	A	S
32d	<1										abu				11/5	G	
MODERATE COVER																	
1	70	35	6	3		10	15		abs	abu			5		7/5	A	U ₁
^a 2	55	30	10	10		9	13		abs	pl			4		7/5	A	U ₁
3	25	40	6	3	2	10	16	20	abs	pr	abu		3	4	9/5	A	U ₂
4	50	25	8	8					abs	abu			5		7/5	A	S
4a	40	30	4	4					abs	pl			5		7/5	A	U ₂
5	<1	8		3						pl			5		9/5	A	
7	80	60	8	8		8			abs	pr			3		14/5	A	S

APPENDIX G - Cont'd.....

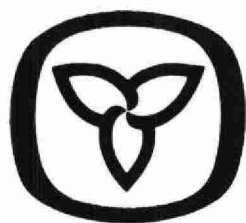
Survey Station No.	Plot Acreage Treated (Approx)	Ave. Tree Height (ft)	Average Water Depth (in.)			Ave.Temp. (°C)			Larval Abundance			Ave.Size (mm)			Treatment Date	Treatment Method	Degree of Larval Control
			Survey No.			Survey No.			Survey No.			Survey No.					
			1	2	3	1	2	3	1	2	3	1	2	3			

MODERATE COVER Cont'd.																	
7b	80		snow	2		snow			abs	abu		5		7/5	A		
8	75	50	4	3	10				abs	abu		2		7/5	A	S	
10	0	60	10	6		10			abs	pr		5					
11	325	20	12	10			15		abs	abu		4		14/5	A	S	
12a	25	8	4	4		14	14		abu	abu		3	4	7/5	A		
12b	0	40	6	5	5		14	19	abs	abu	abu		5	5			
13	14	35	0	4			12		abs	abu		3		7/5	A	S	
14	13	10-40		6			18			abu		4		7/5	A		
16	10	40	8	6		9	15		abs	abu		4		7/5	A	S	
20a	200	70	10	9					abs	pr		5		9/5	A	S	
20b	0	50	5	4		19	16		abu	abu		3	6				
21	0	8	4	4	6	20	21		pl	abu	abu	3	7	7			
22	20	35	13	8		13			abs	pl		5		7/5	A		
24	850	40	3	5	5	8			pr	pl	pl	1	3	5	13/5	A	U ₃
24a		40	8	5		8	16		abs	pr	abu		4	5	13/5	A	
24b		60	7	5		7	12		abs	pr		3		13/5	A		
27	60	55	5	4		10	10		abs	pl		4		7/5	A		
32	850				3			23			pl			7	11/5	A	U ₃
32a		55	9	1		8	18		abs	abs				11/5	A		
32b(i)		20	15	4		3	6		abs	pr		2		11/5	A	U ₁	
32b(ii)		13	12	4		6	8		abs	pr		2		11/5	A	U ₁	
33	200	65	15	6	12	11	6	12	abs	abu	abu	5		11/5	A	U ₁	
34	60	45	12	12	9	9	12		abs	pr	abu	3	5	11/5	A	S	
35	120	75	12	6		8	11		abs	pr	abu	3	6	11/5	A	U ₂	
35a		85	6	3		10	13		abs	abu		4		11/5	A	U ₃	
37	<1	85	10	4	4	10	13	21	abs	pl	abu			6	10/5	G	
43	0	grass	12	12		11	14		abs	pl		4					
47	<1	30			6			20			pl			6	10/5	G	

APPENDIX G - Cont'd.....

Survey Station No.	Plot Acreage Treated (Approx)	Ave. Tree Height (ft)	Average Water Depth (in.)			Ave.Temp.(°C)			Larval Abundance			Ave. Size (mm)			Treatment Date	Treatment Method	Degree of Larval Control
			Survey No.			Survey No.			Survey No.			Survey No.					
			1	2	3	1	2	3	1	2	3	1	2	3			

DENSE COVER																	
A	50	30	6	5	3	5	12		abs	abs	pr		6	14/5	A	U ₃	
A1	10	50	7	5	3		16		abs	pr	pr	3	5	14/5	A	S	
17	200	10	8	7	7	10	15	19	abs	pr	pr	2		15/5	A		
17a		40	8	4		11	14		abs	pl		5		15/5	A		
17b		40	8	5		11	14		abs	pl		5		9/5	A	S	
24d	850	40	6	4		9	14		abs	pl		5		13/5	A		
a 31	200	55	14	14		8	11		pr	pl		3	5	13/5	A	U ₃	
48	<1	30			6			20			pl		6	11/5	G	S	
52a	0	40	12		8	7			abs		abu		6				



Environment Ontario

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APPENDIX H

MOSQUITO CONTROL IN MARA TOWNSHIP

COUNTY OF ONTARIO

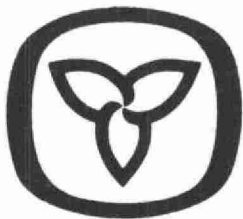
AUGUST 28TH 1972

The Biology Section, Water Quality Branch of the Ministry of the Environment (formerly within the Ontario Water Resources Commission) has, over the past several years, devoted considerable attention to the feasibility of controlling mosquito populations within that region of Mara Township which extends from Orillia in the north, to Beaverton in the south, and to a distance approximately 3 miles inland from the shore of Lake Simcoe.

At the request of the Township authorities permits were issued for larviciding operations in 1968, 1969 and 1971 with a second, follow-up spray being undertaken in mid-summer of 1968 to control adult mosquitos. In addition, Township personnel undertook periodic fogging to control adult mosquitos along roadsides adjacent to cottage properties over the summers of 1970, 1971 and 1972. This questionnaire is being distributed to the majority of residents of Mara Township within the control zone to assist the Ministry in evaluating the effect of these treatments as well as to determine the attitudes of the people towards mosquito control measures.

In requesting your co-operation by providing answers to the questions which follow, the Ministry wishes to emphasize that the results of this survey will not in themselves be used to formulate plans for future mosquito control programs in Mara Township. The Ministry is anxious to ensure that all policies concerning biting fly control in the Province of Ontario be established with a firm understanding of the efficacy, safety and cost of such measures and with full knowledge of the public attitude toward biting fly problems. The information obtained from the questionnaire will constitute an important step in meeting these obligations.

Please answer the questions at your earliest convenience and return the completed questionnaire by September 8th, 1972.



Environment Ontario

MARA TOWNSHIP MOSQUITO CONTROL QUESTIONNAIRE

SUMMER 1972

YOUR NAME AND ADDRESS ARE NOT REQUIRED

1. Are you: A permanent resident of Mara Township? _____
OR
A seasonal resident? _____
2. How many years have you resided or vacationed in this area? _____
3. a. As far as possible, mark the following periods in order of mosquito severity using the number 1 for the period during which you feel the mosquito populations were greatest.
Prior to 1950 _____
From 1951 to 1960 _____
From 1961 to 1967 _____
From 1968 to the present _____
- b. As far as possible, mark the following years in order of mosquito severity, using the same system as in question 3.a.
1967 _____
1968 _____
1969 _____
1970 _____
1971 _____
1972 _____

4. Mark the following times of year in order of mosquito severity, using the same system as in question 3.a.

N.B. Mark only those periods with which you are familiar.

Mid-May to end of June	_____
July and August	_____
September	_____

5. Which of the following times of day do you consider to be the worst with respect to mosquito biting?

N.B. Mark one only

Early morning	_____
Daylight hours	_____
Sundown	_____
Early morning and sundown the same	_____

6. Which of the following types of activities do you feel are severely affected by mosquitos in Mara Township. Tick as many as are appropriate.

Outdoor, land based	_____
Outdoor, water based	_____
Indoor	_____
Business	_____
None of the above	_____

7. By comparison with other rural areas of Ontario with which you are familiar, would you say that the situation in Mara Township is:

More severe	_____
Less severe	_____
The same	_____
Not sure	_____

8. a. Are you in favor of mosquito control in Mara Township?

Yes

No

- b. If your answer to the above is yes, which of the following control measures would you support?

The continued spraying of insecticides to:

Control mosquito larvae

Control adult mosquitos

Both of the above

OR

Some alternative method of control such as reducing the area of mosquito habitat by improving land drainage

- c. In relation to the above question, how much would you be willing to contribute annually toward the control method of your choosing?

Up to ten dollars

Up to twenty dollars

Up to fifty dollars

Nothing at all

Please return completed questionnaire in the stamped addressed envelope provided, before September 8th, 1972.



(7798)

MOE/MAR/MOS/ALWT

DATE DUE		

MOE/MAR/MOS/ALWT

Boelens, R.G.V

Mosquito control in

Ontario with alwt

c.1 a aa